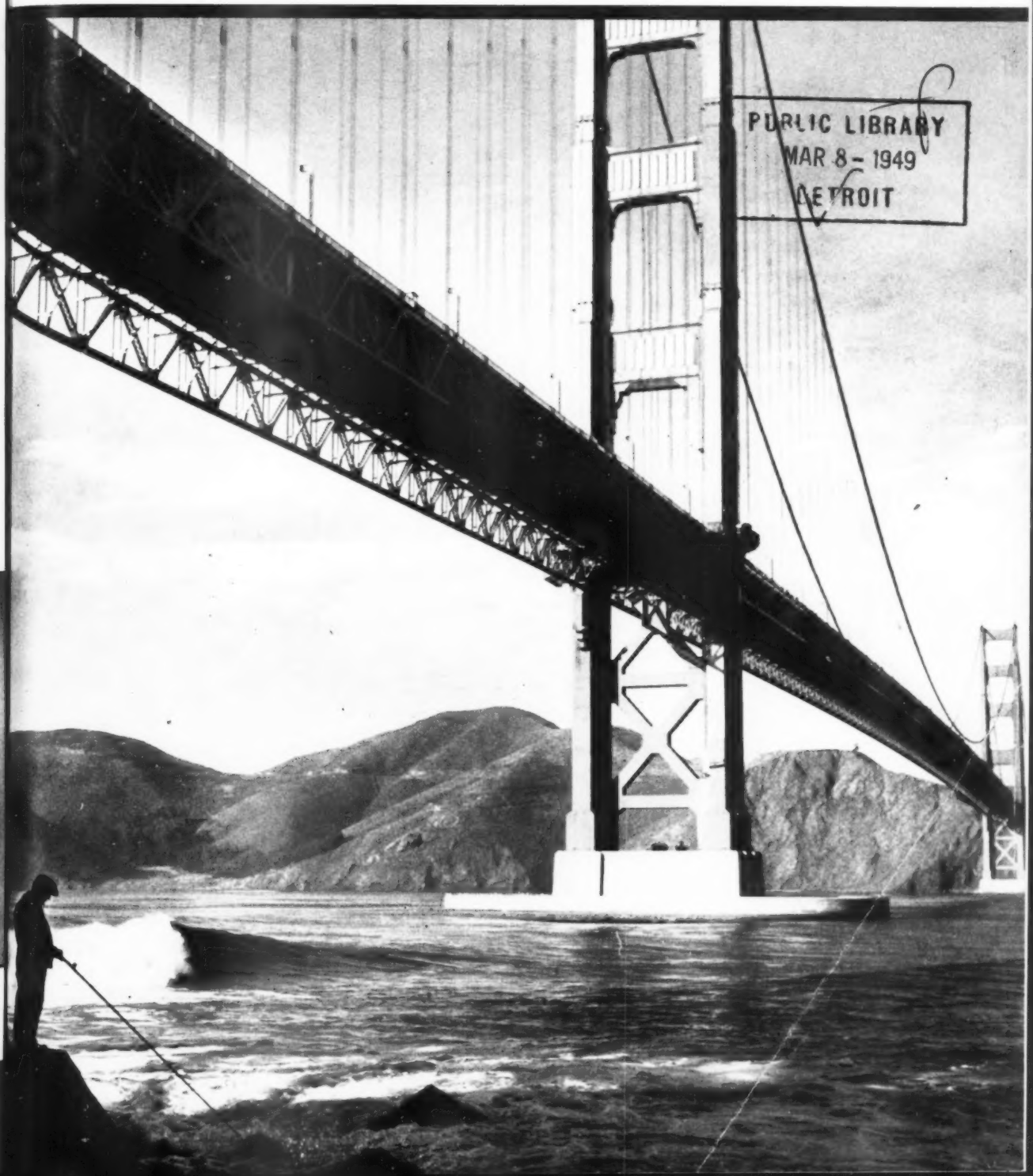
ECHNOLOGY DEPARTMENT

TECHNOLOGY REVIEW

March 1949



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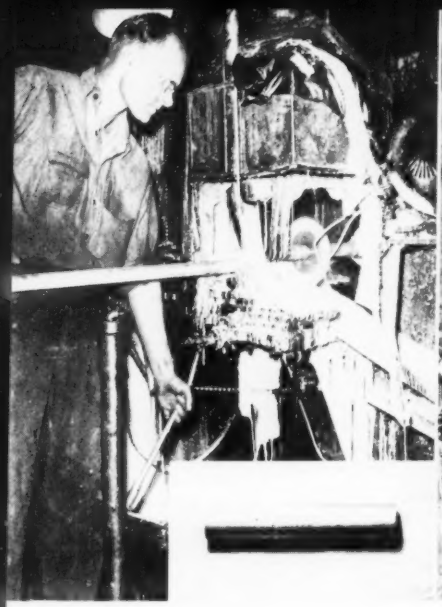
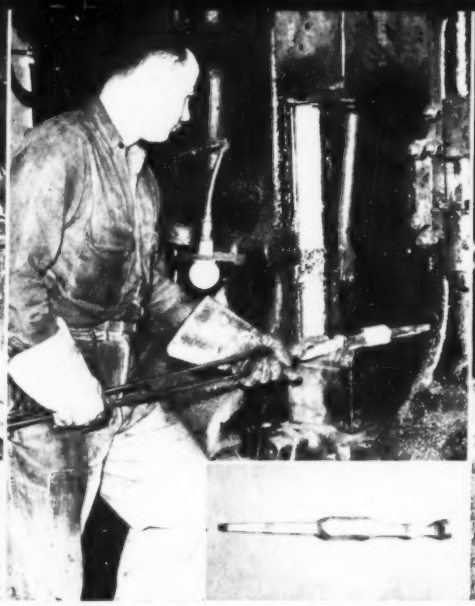
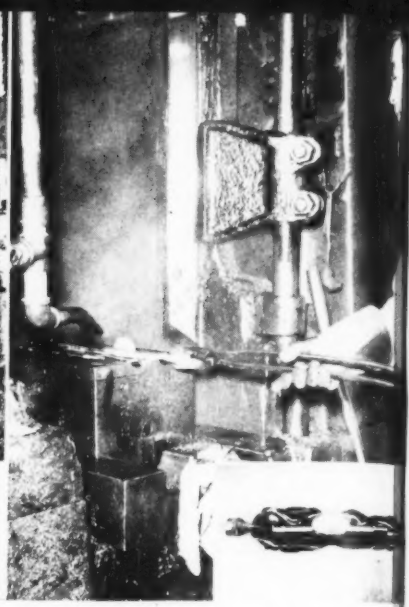
DETROIT



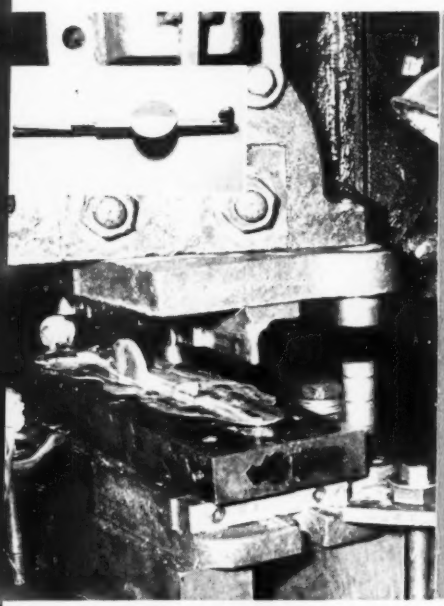
Cutting Bar



Lengthening and Shaping



Shaping to the Die



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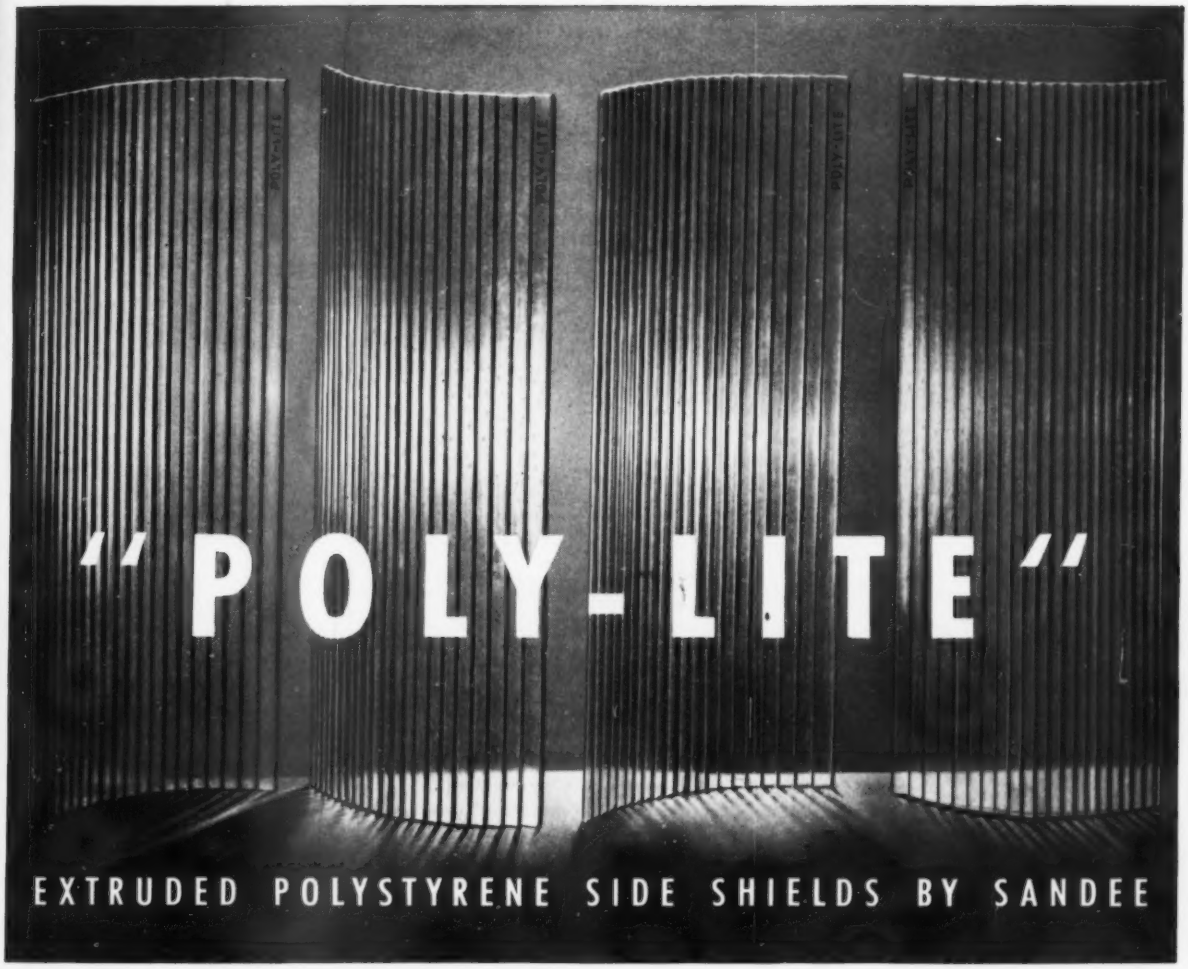

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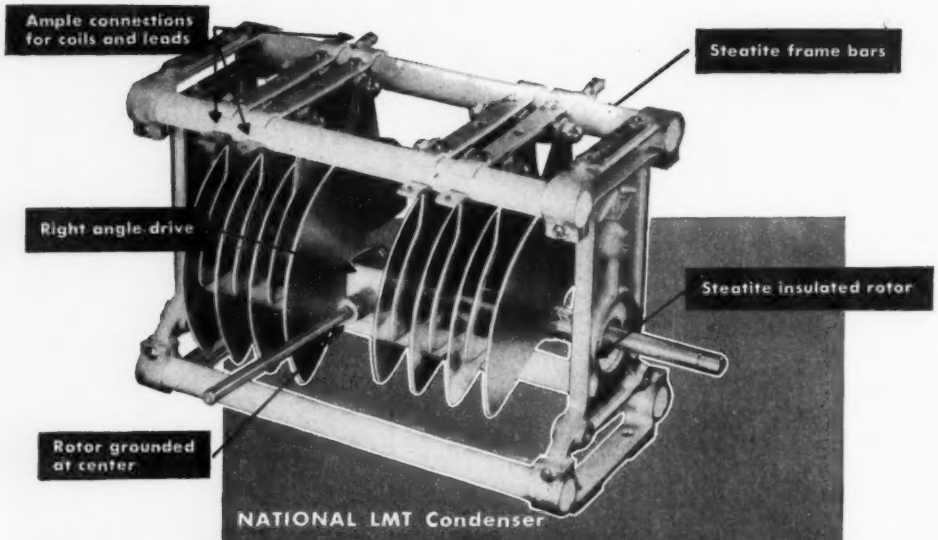
EXTRUDED PLASTICS AND SPECIAL TOOLS

THE TECHNOLOGY REVIEW, March, 1949. Newsstand Edition. Vol. LI, No. 5. Published monthly from November to July inclusive at 8 Harmony Place, Brattleboro, Vt. Publication date: twenty-seventh of the month preceding date of issue. Annual subscription $3.50; Canadian and Foreign subscription, $4.00. Entered as second-class matter at the Post Office at Brattleboro, Vt., under the Act of March 3, 1879.



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Catalog Symbol	Capacity	Peak Voltage	Net
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LMT-30DEG	30-30 Mmf.	20,000v.	$22.45
LMT-60DDG	60-60	15,000v.	24.05
LMT-100DBG	100-100	10,000v.	16.25
LMT-60DBG	60-60	10,000v.	23.05
LMT-200DAG	200-200	7,500v.	28.50
LMT-100DAG	100-100	7,500v.	24.05
DOUBLE STATOR MODELS			
LMT-30DE	30-30 Mmf.	20,000v.	$18.55
LMT-60DD	60-60	15,000v.	20.15
LMT-100DB	100-100	10,000v.	12.35
LMT-60DB	60-60	10,000v.	19.15
LMT-200DA	200-200	7,500v.	24.60
LMT-100DA	100-100	7,500v.	20.15

Catalog Symbol	Capacity	Peak Voltage	Net
SINGLE STATOR MODELS			
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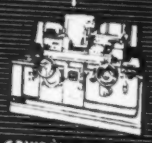
LMT-150D	150	15,000v.	18.50
LMT-100D	100	15,000v.	16.60
LMT-50D	50	15,000v.	11.50
LMT-245B	245	10,000v.	20.15
LMT-150B	150	10,000v.	18.35
LMT-100B	100	10,000v.	17.55
LMT-75B	75	10,000v.	12.80
LMT-500A	500	7,500v.	24.60
LMT-350A	350	7,500v.	19.65
LMT-250A	250	7,500v.	18.35

GRINDING WHEELS

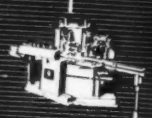


GRINDING MACHINES

REFRACTORIES

NORBIDE

NON-SLIP FLOORS



LABELING MACHINES

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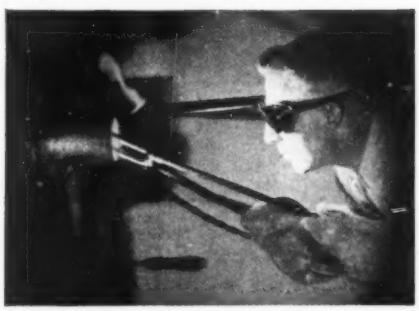

Industry Uses These Temperatures Today . . . with Norton-Developed Refractories

TEMPERATURES as high as 4300° F. for the sintering of carbides . . . up to 4700° F. in the manufacture of acetylene . . . even up to 5500° F. in certain research projects . . . that's the way industry is using heat today. And to handle this heat it is turning to Norton.

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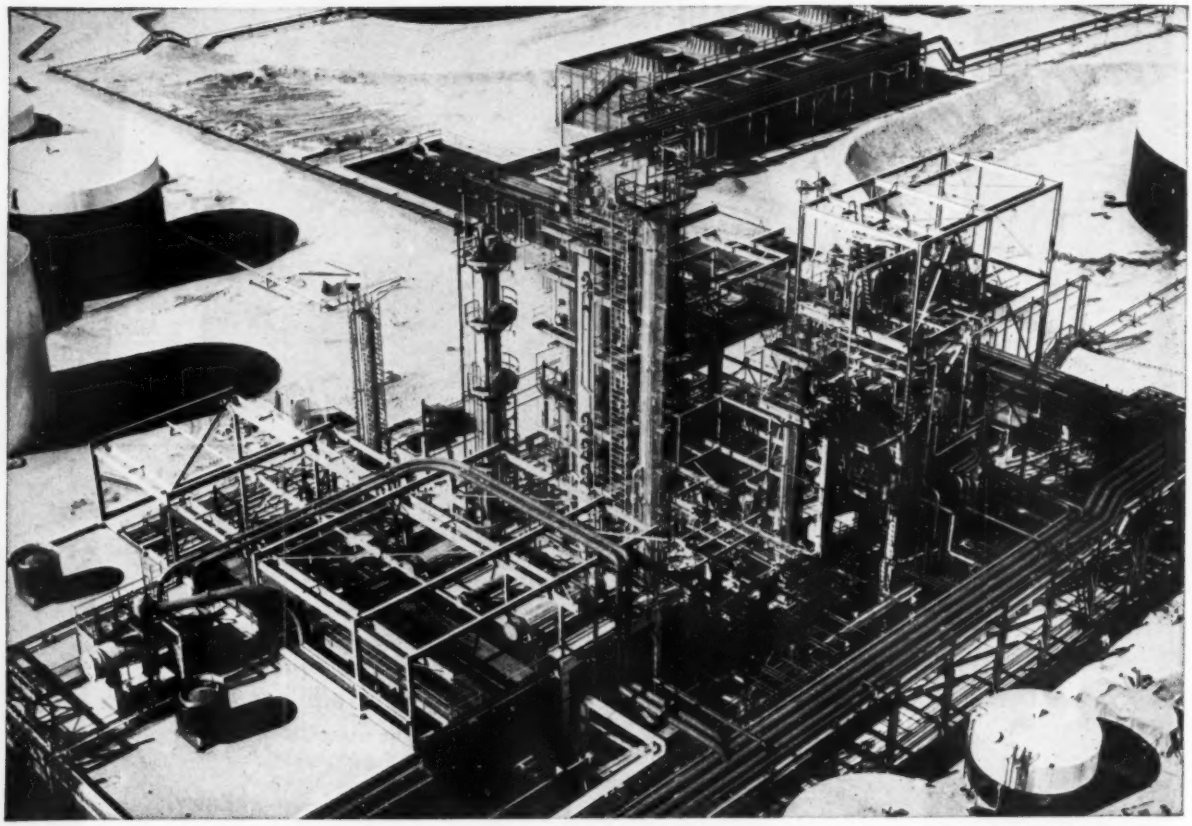

Denver, Colorado Refinery of Continental Oil Company, with catalytic cracking, gas recovery, catalytic polymerization and L.P.G. Fractionating units designed and built by Lummus.

...an interesting example of integrated expansion

The new Lummus-built catalytic cracking unit at Continental's Denver Refinery was recently completed. Despite unfavorable weather conditions it went on stream about the middle of November, and within two days it was operating at design capacity.

The catalytic cracking unit was part of an integrated expansion program that included the design and construction by Lummus of three other new units—gas recovery, catalytic polymerization, liquid propane gas fractionation—and the modernization by Lummus of a thermal cracking unit.

Continental's Denver Program is an interesting example of refinery expansion accomplished by integrating new units with modernized existing facilities. This program practically doubles the crude thruput at Denver and raises the octane level of the finished gasoline.

Lummus engineers are available for a thorough study of individual problems involving the modernization or expansion of existing facilities and the projection of new programs.

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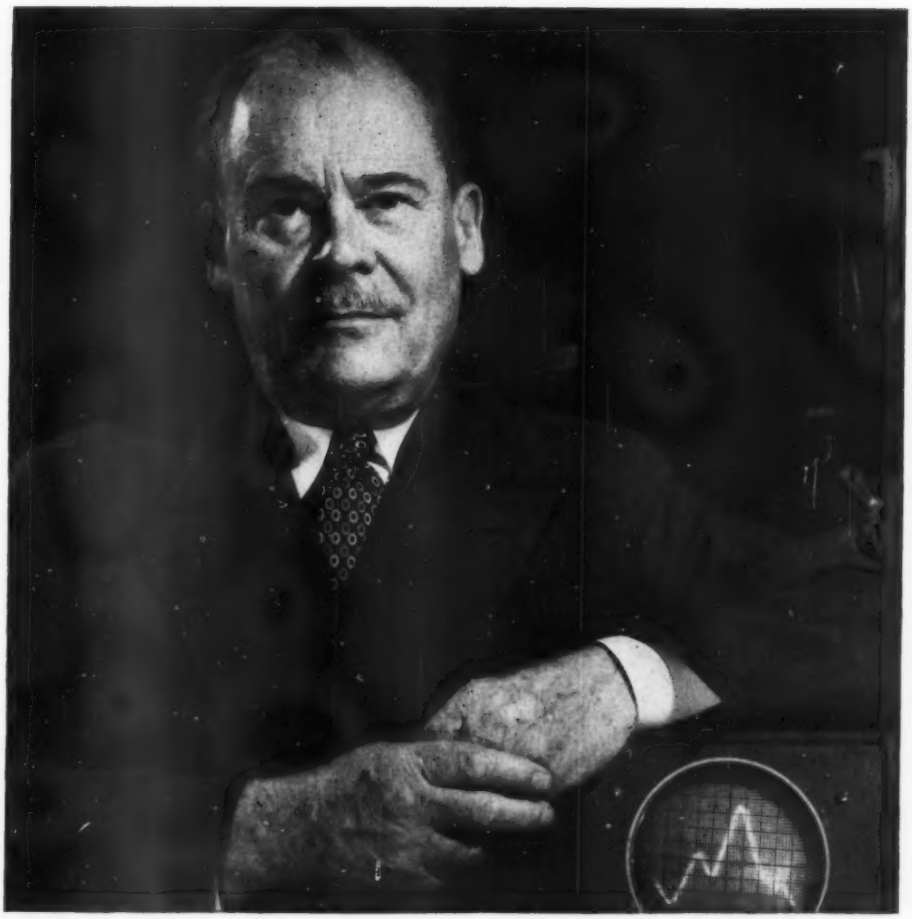
OIL STEEL CHEMICAL



An Invention EVERY SEVEN WEEKS

IN 46 years with General Electric, Dr. Ernst F. W. Alexanderson has directed his experiments into many fields to his liking—into radio, television, motors, generators, electric traction, electric ship propulsion, power transmission.

To these varied industries he has contributed 313 patents, an average of one every seven weeks.

Emphasis on research and creative engineering, encouragement of fertile minds to follow their own imaginative bent—these are part of the General Electric tradition. General Electric has more than a score of laboratories devoted to the problems of fundamental research, engineering, measurement, manufacturing, and testing. Today General Electric employs the largest staff of scientists and engineers in industry.

During the past ten years these men and women have developed over 8000 new, patentable ideas—more than two each day.

These facts are important to the consumer who wants to know that the products he buys are backed by creative thinking, by progressive engineering, and by expert skill.

You can put your confidence in

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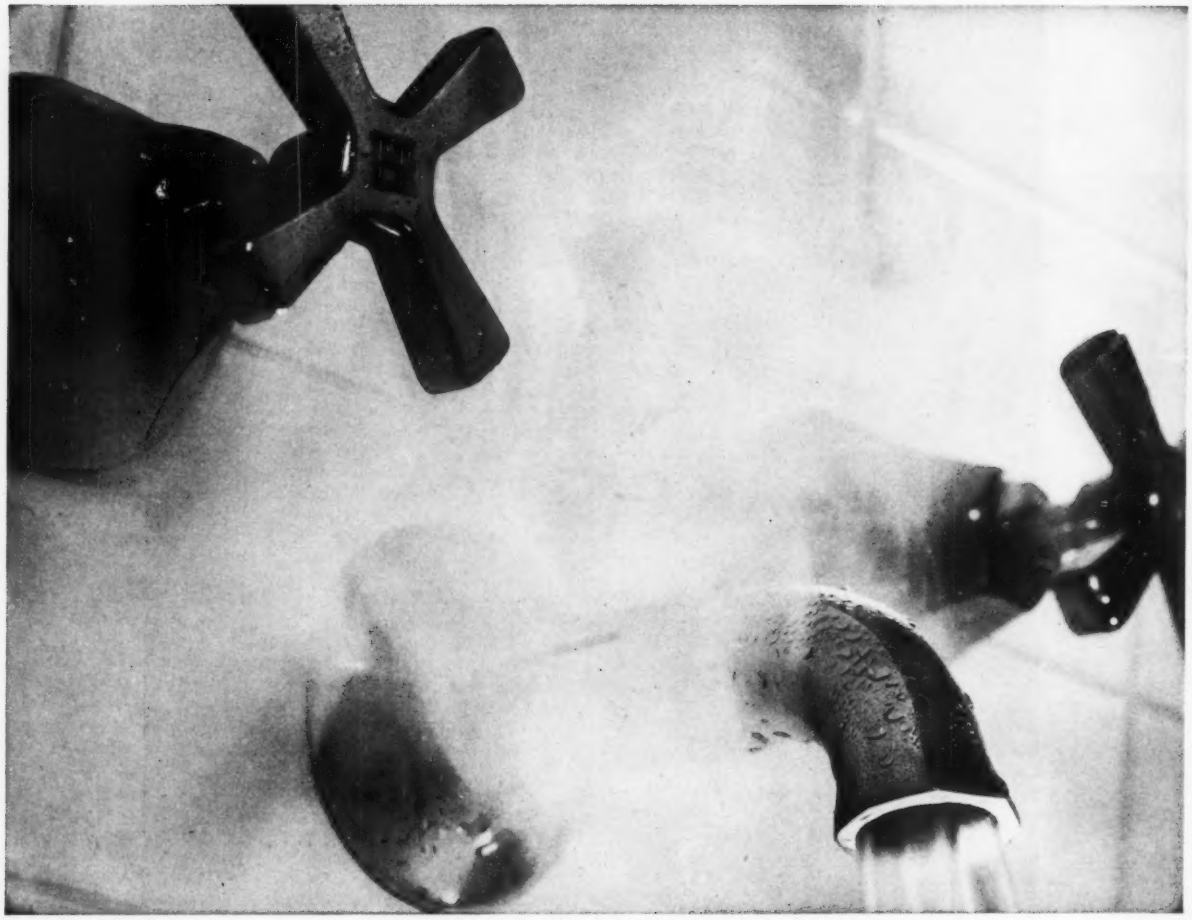

Comfort on tap

To millions of American families, water —piping hot—is a modern luxury that is taken for granted. For tub and shower, laundry and dishes, and a myriad of household chores, we turn the handle of a faucet and automatically receive a warm abundance.

To you, perhaps, Combustion has always been a name associated with steam generation for industrial needs—with boilers that range in size up to the height of a 12-story building and consume a carload of coal to produce a million pounds of steam in a single hour. Yet, in hundreds of thousands of homes, C-E means comfort on tap—abundant hot water from a C-E Heatmaster® or Reddyhot® Automatic Water Heater, using gas (either natural, manufactured, or bottled) or electricity as fuel.

It's a long step from a few gallons of hot water to a million pounds of steam, but a logical one for C-E, for the water heater and the million-pound boiler basically have the same function—burning fuel to transmit heat to water. And, as you would expect, the knowledge, experience and facilities that have made C-E boilers pre-eminent in industry have placed C-E water heaters high among the leaders in the domestic field.

Between the simplicity of domestic water heaters and the complexity of the world's largest boilers lie many seemingly unrelated C-E products, linked by the common purpose of generating and applying heat. All are identified by the C-E Flame . . . a mark that symbolizes Combustion's 60 years of specialized experience in the efficient use of heat.

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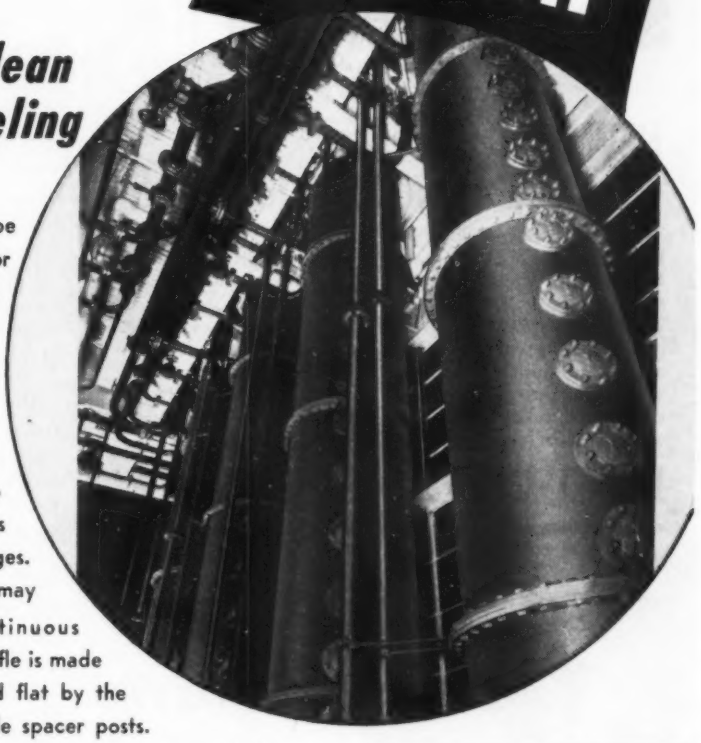

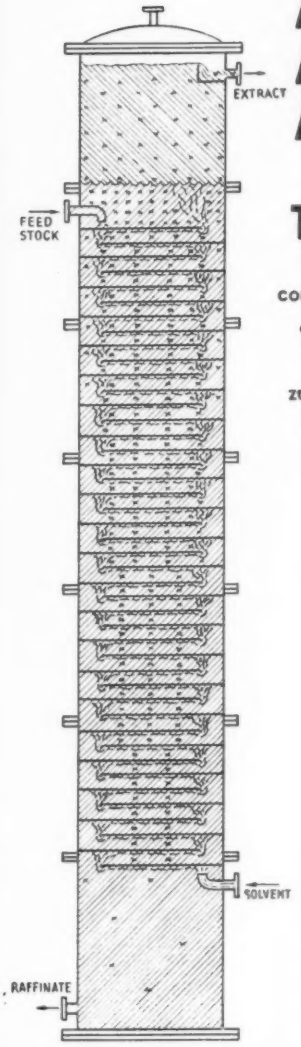

Diagrammatic sketch of a liquid-liquid extraction column

THE Vulcan baffle-type liquid-liquid extractor consists of a vertical column packed with a series of horizontal baffles. The turbulent region at the edge of each baffle serves to remix the liquids between stages. Either phase may be the continuous phase. Each baffle is made horizontal and flat by the use of adjustable spacer posts.

This equipment has been highly successful in the organic chemical industry and it is equally suitable for hydrocarbon separations. Each new application is carefully checked in the Vulcan laboratories to assure economical design and to permit performance guarantees.

These extractors are available in all corrosion resistant materials and in diameters to ten feet.

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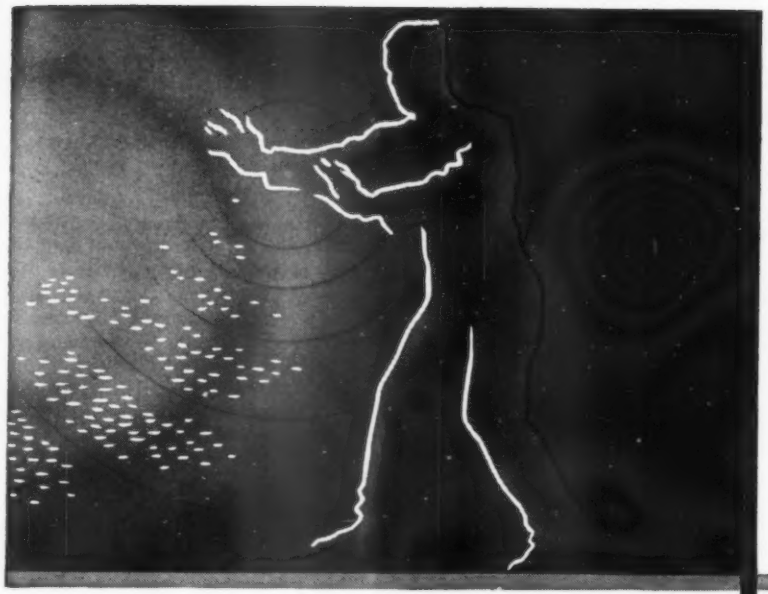
THE TABULAR VIEW

Earth-Wise Engineers. — With the world's population increasing rapidly, and the arable regions suitable for agriculture, limited in extent, one of the world's major problems is that of preserving and making the fullest possible uses of natural resources. In this problem the engineer has a role to play fully as important as the professional soil conservationist. When both work together, to achieve the same desirable aims, the result cannot be other than good. In his article (page 269) EDWARD H. GRAHAM, whose major field is botany and the ecological aspects of land management, outlines means by which engineers may make effective contributions to soil-conservation practices. Dr. Graham, a graduate of the University of Pittsburgh (B.S., 1927; Ph.D., 1932), is chief of the Biology Division of the Soil Conservation Service in Washington, D.C. His article in this issue is the second of two lectures to students in civil engineering last year; the first appeared in the February, 1949, issue of The Review.

Closed for Repairs. — The lessons learned during wars often serve humanity much more effectively in time of peace. To the ample evidences in the field of medicine, this issue of The Review adds one in the field of engineering in the article (page 275) by WERNER H. GUMPERTZ, '48. Mr. Gumpertz studied at the Swiss Federal Institute of Technology from 1936–1939, and from 1940–1943 worked as an engineer in the states of New York, Virginia, and Washington. Between 1943 and 1946 he saw service in the Intelligence Division of the United States Army. Until 1947 he was head of the Structural Unit, Operations Branch, Office of the Chief Engineer, European Command, United States Army. His article is the winning paper submitted last June for the Samuel Stratton Prize for undergraduates.

Microphone Buttons and Violin Bows. — The story on architectural acoustics (page 279) by R. H. BOLT and A. M. CLARKE in this issue should provide ample refutation to those critics who hold that modern technical education is too highly specialized, narrow, and fails to recognize the humanitarian purpose of its objectives. Dr. Bolt, a graduate of the University of California (A.B., 1933; A.M., 1937; Ph.D., 1939) took undergraduate work in music and architecture, and graduate work in physics, education, and engineering. His diversified training is put to good use in organizing and directing the graduate program in acoustics. He has been at M.I.T. since 1939, and director of the Institute's Acoustics Laboratory since its formation in 1946. Dr. Bolt is president-elect of the Acoustical Society of America and will assume duties of this elective post in May. Currently editor of the Acoustics Laboratory reports, A. M. Clarke has been associate editor of the Office of Scientific Research and Development-sponsored publication *Radar* of the Army Air Forces, and assistant editor of *Radar Systems Engineering*, one of 29 volumes in the Radiation Laboratory Series.



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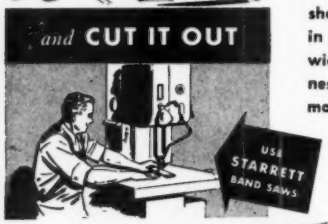

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MAIL RETURNS

Comment on Engineering Membership

FROM JAMES F. FOUHY, '05:

I am calling your attention to an omission in your February issue on the chart shown on page 212 and entitled "Growth of Membership of Engineering Societies in the United States." You show charts for a number of societies, but neglect entirely the National Society of Professional Engineers. This organization, according to the January, 1949, edition of its magazine *American Engineer* had a membership on November 30, 1948, of 19,164.

The National Society of Professional Engineers is the only organization of engineers, insofar as I know, which consists entirely of engineers licensed by their respective states. Considering this point, and the further fact that membership is easily acquired in many of the societies shown on the diagram, it would appear that a gross error has been made, and in the opinion of the writer should be rectified in an early number.

Incidentally, the executive director of the National Society of Professional Engineers is a Technology graduate. His name is Paul H. Robbins of the Class of 1936.
New York, N. Y.

[*The Review is pleased to have, and to publish, Mr. Fouhy's comment on the membership of the National Society of Professional Engineers. The Trend of Affairs item in the February issue was intended merely to provide some measure, however rough, of the growth of engineering in the United States during the past three-quarters century. In presenting membership data on a few selected societies, it was obviously necessary to "neglect entirely" inclusion of figures for many engineering groups, including those of the National Society of Professional Engineers which, we are informed, was organized in 1934. We hasten to assure our readers — as well as Messrs. Fouhy and Robbins — that The Review had no intention of slighting any organization or group of engineers through errors of omission in presenting the data on "Our Engineering Population" in the February issue. — Ed.*]

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The use of better materials to make steel go farther and serve longer is especially vital to all of us . . . with steel mills unable to catch up, and ore supplies dwindling.

Industrial gases have a big role in steel's better performance, too. Compressed oxygen aids in cleansing the molten steel . . . the oxy-acetylene torch cuts steel sections to size—and welds them together if desired. Finished steel articles are given a harder, longer-wearing surface through "flame-hardening." And carbon, in the form of electrodes, makes modern electric furnaces possible . . . with their output of high quality steels.

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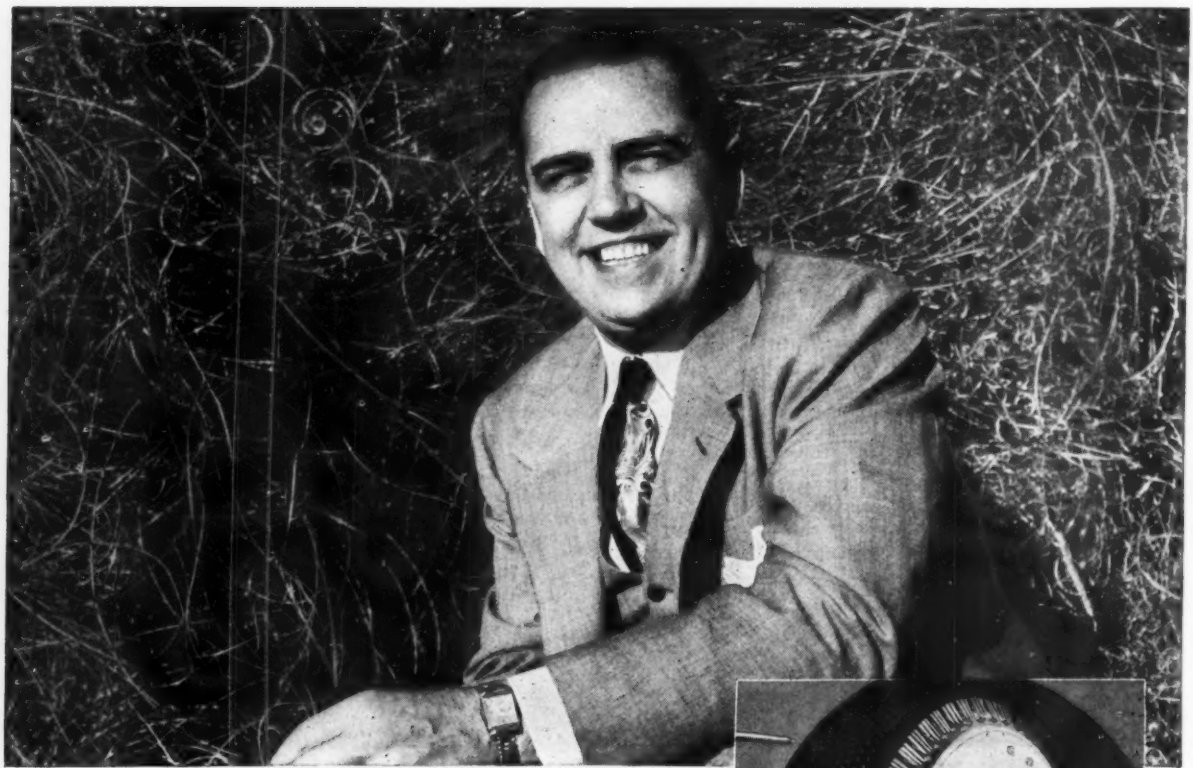

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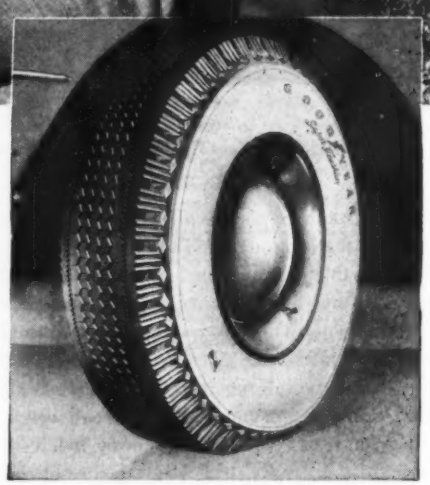

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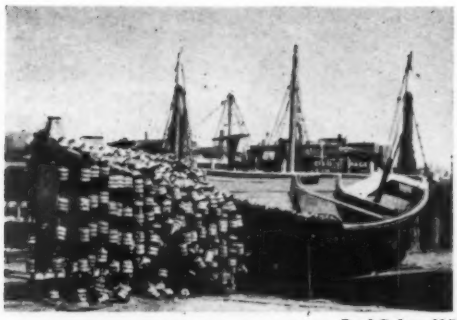

Paul Cohen, '35

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VOL. 51 NO. 5

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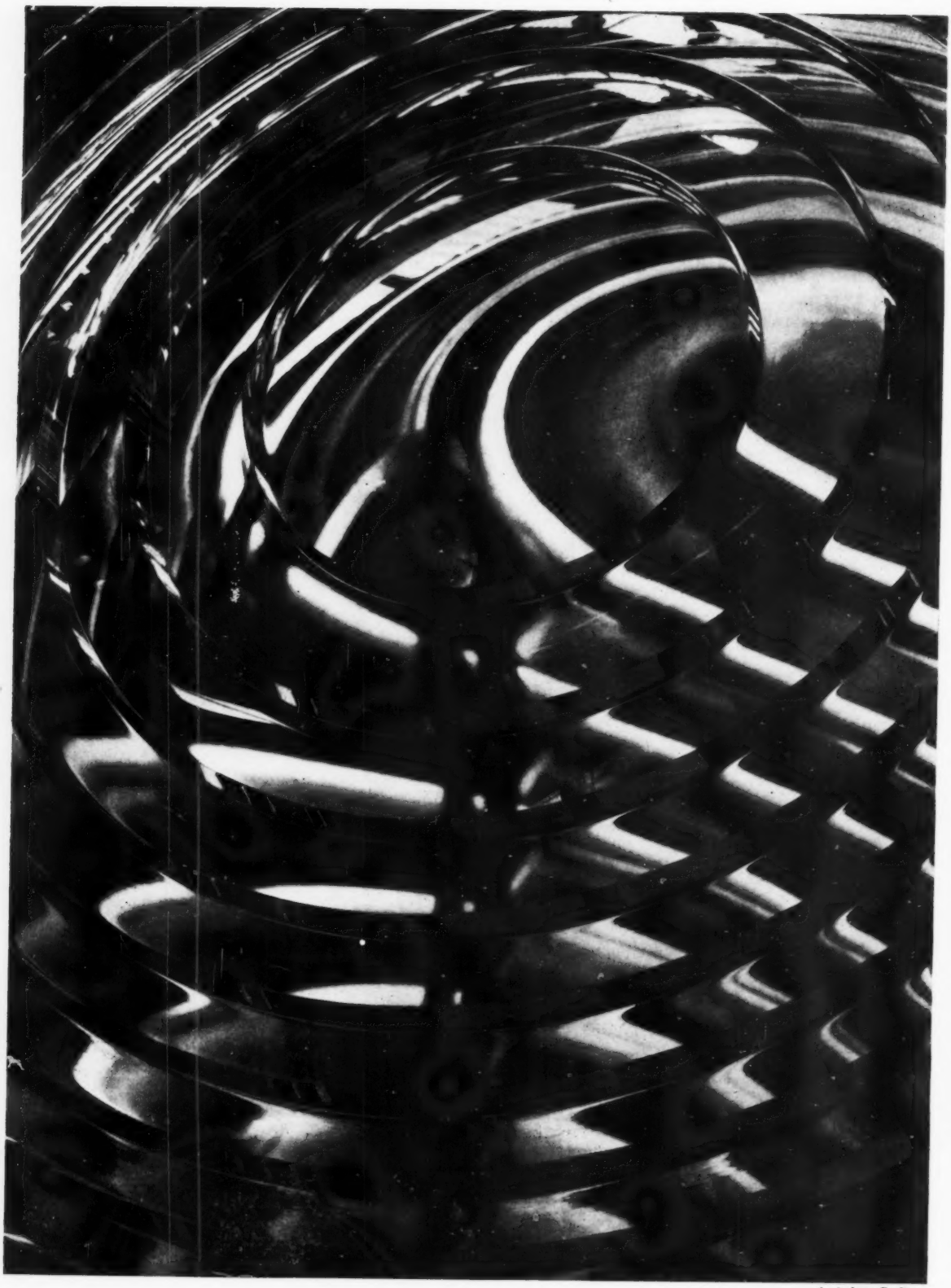


A. Aubrey Bodine

Pattern in Optics

THE
TECHNOLOGY REVIEW

Vol. 51, No. 5 March, 1949

The Trend of Affairs

This Artificial Life

TIME was when chicle and chewing gum were synonymous, and the inexorable demands of wagging American jaws provided security for thousands of Mexican laborers, and, weather permitting, many millions of dollars in American exchange. The lush of an earlier era has dwindled and now one of the problems facing the Mexican Government at the moment is what to do about the chicle gatherers in the Mexican states of Campeche, Quintana Roo, and Chiapas. These areas, down at the southern and rainy end of Mexico, produce about 90 per cent of the world's supply of chicle.

Chewing gum manufacturers have discovered that synthetic resins of the coumarone-indene type (known since the 1890's and made from coal-tar derivatives) form highly satisfactory bases for chewing gums. These resins find ready use because their viscosities can be controlled over a very wide range, and because they have ready compatibility with a large number of natural gums, waxes, oils and flavors. Other resins are also being used – or are under study – for use in the manufacture of chewing gum. Unlike raw chicle, which comes to this country in various grades and colors, and which must be vigorously cleaned of sand, dirt, bark and other assorted debris before further processing, the synthetic resins can be supplied to meet precisely defined specifications. At last reports they also appeared to hold some price advantage. Nor are they liable to become in short supply because of a season of low rainfall. Thus, research on synthetic resins has greatly affected the economic status of chicle gatherers of southern Mexico who may, perhaps, be excused for believing that "research is what makes securities insecure" as a banker once said. In Mexico efforts have been directed of late to the building up of a domestic chewing gum industry in order to keep chicle production somewhere near present levels.

Mexican output of chicle has been in the order of 20,000,000 pounds per year. This makes it one of the more substantial of our variegated imports of gums, roots, and other botanicals that total approximately 50,000 tons per year. For example, our food and medicinal industries find use for such imported roots as licorice, sarsaparilla, ipecac, gentian, galangal (ginger), Culver's, and jalap. While on this aspect of the American diet, it is interesting to observe that the production of synthetic medicinals is now on such a scale that it bears comparison with the use of natural products. This country produced nearly 10,000,000 pounds of acetylsalicylic acid (aspirin) in 1946, over 5,000,000 pounds of sulfa drugs, and considerably more than 1,000,000 pounds of the various vitamin B's, all of which are produced to ease the burden of our somewhat artificial lives.

Silver Bearings

THE massive industrial use of silver during the recent conflict, in such completely salvageable applications as bus bars and transformer windings, may be dismissed as an aspect of total war. More typical of the paradoxes that occasionally result from the interaction of engineering and economics is the growing use of silver in crankshaft and other heavy duty bearings. In 1947, about 360,000 pounds of a silver-lead "babbit" alloy was used in this country; and a fair amount of 99.5 per cent pure silver went into airplane-engine bearings.

The alloy contains only about 2.6 per cent of silver, the remainder being mainly lead and antimony, so that the total silver content in 1947 amounted to less than 10,000 pounds. Tin, the traditional base for bearing alloys, is a far more abundant metal than silver, total world production being 20 or 30 times as great. But when production from our own mines is considered, five tons of silver is an insignificant percent-

age; five tons of tin would represent virtually our total output in 1942, 1943, or 1944. Substitution, taking place on economic and engineering merits, is also bettering our position in regard to strategic materials.

Silver has much to recommend it as a bearing material. It is relatively tough and strong; it is the best heat conductor known; and it melts at a temperature high enough so that no minor or local overheating will cause a failure. On the other hand, it is not soft enough to permit an occasional grain of sand or grit to embed itself, and thus prevent scoring of smooth bearing surfaces. Lead, however, has high "embeddability." Therefore the alloy.

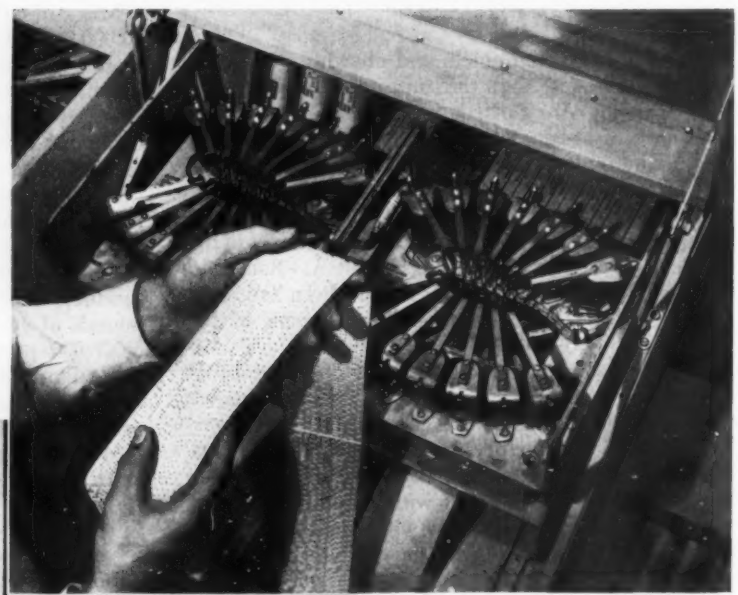
In airplane-engine bearings, silver is used in quite another manner, for here the cost of material becomes irrelevant in the face of bettered performance. One of the few inescapable criteria that determine how big a reciprocating engine shall be for a given horsepower is the loading that its crankshaft bearings can take. In the airplane, particularly, a saving in weight in the engine is compounded many times in the over-all structure. Previous to the silver bearings, which are now standard in the industry, the bearings were of babbitt or copper-lead alloys backed up with steel to supply the compressive strength that these more "embedable" materials lacked.

Silver was introduced just before the beginning of World War II, but when used alone, performance was sometimes inconsistent because of its hardness. The cure proved to be a thin layer (about .001 inch) of lead electroplated over the silver. But lead tends to corrode in the lubricating oils used in airplane engines, and this layer, thinner than the ordinary sheet of paper, was soon alloyed with iridium or tin. The steel backing shell was of course retained. When it was found that silver cast directly against the steel did not give a sufficiently reliable bond, resort was made to electroplating. A thickness of about .020 inch is required, however, and silver is usually plated at a rate of about .001 inch per hour. Production methods have been developed, therefore, that permit .015 inch of silver to be deposited in an hour, with still faster rates possible in the laboratory. As a final refinement, the steel shell is struck with an extremely thin layer of copper or nickel to promote maximum adhesion of the silver. So, in effect, today's propeller-driven airplanes roll through the sky on a sandwich of steel, nickel, silver, and lead-iridium alloy.

Automatic Telephone Billing

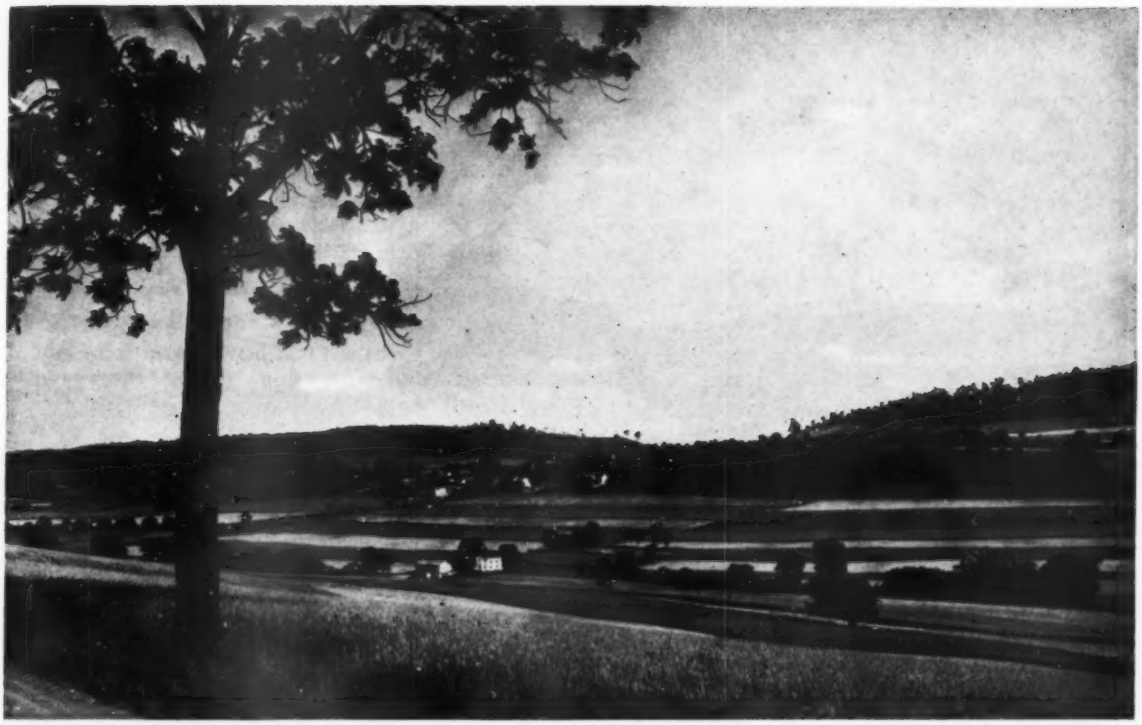
An automatic accounting system which can keep track of thousands of dial telephone calls is the latest contribution of the Bell Telephone Laboratories to telephone service. The new service, which will "remember" who made calls, what numbers were called, how long the conversations lasted, and then add up and print detailed charge information is regarded as one of the most significant advances in telephone engineering since the introduction of the dial system. First installation was made recently in Philadelphia.

Nick Lazarnick



Nick Lazarnick

(Above) *Heart of the new automatic message accounting system is the tape-punching equipment. Punched paper tape contains information on the calling and called numbers, length of call, and date, for thousands of telephone calls.* (Left) *Coded punched tape is run through reader machines and the data punched on it are assembled, sorted, and summarized. Machines in the accounting center print individual bills from this data. A tape reel, such as that shown here, holds billing information for as many as 25,000 telephone calls.*



Soil Conservation Service

ENGINEERING IN THE SERVICE OF Soil Conservation

Without the Help of the Engineer We Cannot Achieve Conservation of the Soil or Wise Use of Any of Our Natural Resources

By **EDWARD H. GRAHAM**

SOIL conservation is the use of land according to its capability, and the treatment of land according to its needs. This concept includes all kinds of land. Land is the base without which we could have no cultivated crops, no timber or wood products, no meat or livestock products, such as leather and wool, and no wild life. All of these renewable resources are dependent upon the soil. Without soil conservation these vital materials are endangered. Without soil conservation applied to the land we cannot have clear streams or ponds and reservoirs free of sediment.

One of the most important facts in conservation is that its phases are so closely interrelated that we cannot rightly think of one phase without consideration of the other. Forest conservation means little without conservation of the soil upon which trees depend for growth. Soil conservation is so closely related to water conservation that the two cannot rightly be separated. The technician who helps a farmer or rancher make a conservation plan for his land cannot do an adequate job unless he is trained and capable of understanding something of the treatments required for cropland, pasture, wood lot, range land, wild-life land, and the water-control system needed on the entire acreage. In the thinking of this technician, and to a large extent in the mind of the farmer he works with, there must be a concept of the wholeness of the unit of land upon which they are working, and the understanding that whatever is done on one parcel of land may have its effect upon another.

This need for co-ordination is recognized by the Civil Service Commission in its requirements for the position of soil conservationist in the Federal government. The beginning soil conservationist is employed as a farm planner to help the farmer or rancher develop a conservation plan for an individual operating unit of land, and determine soil- and water-conservation practices needed.

To obtain a Federal job as a soil conservationist in the beginning professional grade, an applicant must have successfully completed a full four-year accredited college course, or its equivalent, in soil conserva-

Ward Allan Howe

◀ NORTHEAST

This pastoral scene in the Ischua Valley, near Franklinville, N.Y., is representative of the conditions to be found in the northeast part of the United States. The growing season is about a third of a year and rainfall varies from 30 to 50 inches. In this region of rolling and sloping land the major erosion is sheet erosion.

Soil Conservation Service

SOUTHEAST ▶

Gullies, some of them like miniature Grand Canyons, are common in the Southeast, as this photograph of a farm in Georgia clearly shows. Here, a non-co-operative farmer has just finished cutting off all timber and has piled it into gullies, merely adding to the already severe erosion in this part of the country.

tion or in a closely related agricultural science, including civil or hydraulic engineering. Emphasis is placed on the desirability of broadening the range of subject-matter courses in accordance with the co-ordinated approach to soil conservation work. It is desirable if the applicant has had at least one course in each of the following subject groups: soils or soil conservation; woodland management, plant ecology, or economic biology; farm crops or pasture management; feeds and feeding or animal nutrition; farm or ranch management or agricultural economics; and farm drainage or hydraulics, hydrology or plane surveying.

Some of these subjects may not represent much engineering and, in fact, several do not. The point is that no soil conservationist or farm planner can understand land capabilities and recommended treatments, or work intelligently with land operators, unless he knows enough about plane surveying to run lines for contour cultivation and and other simple conservation practices, and also knows enough about the behavior of water to call for the aid of an engineering specialist when one is needed. A simple understanding of the other sciences mentioned is likewise necessary.

The farm planner is responsible for recognizing the need for, and the inclusion of, the required engineering practices in the farm conservation plan. He must have sufficient training to recognize the place of engineering in the plan, and at the same time, recognize his limitations in the design and layout of engineering practices and structures. Farm planners may do surveying and layout work necessary for the installation of engineering practices, such as terrace systems, vegetated waterways, field drains, and other works of similar nature, based on demonstrated ability.

The Soil Conservation Engineer

There are a great many soil- and water-conservation practices requiring special engineering skill that must be applied to the land as part of a complete conservation plan. They must be closely integrated with agronomic, forestry, range management, biological, and other practices to effectuate the plan. Without them, it is often impossible to make the other practices do the job they are intended to do. To design them and aid in their application, the services of a well-qualified engineer are necessary.

It may be well at this point to mention some of the engineering practices used in soil- and water-conservation work. Some of the most generally useful of them are contour furrowing, diversion channels, drainage, including use of covered and open drains, water storage and soil-saving dams, diversion dams,

spring development, wells, construction of canals, farm water distribution systems, land leveling, controlled flooding of irrigated fields, construction of outlets and farm water courses, water-spreading systems, and terracing. Many of these practices are applicable to cropland. Some are also useful in pastures or on western range land. Others are especially useful in irrigated sections. Some can be used in woodland or in marshes and swamps. Soil-conservation practices requiring the services of an engineer are not confined to any particular type of land.

Contributions of Engineers

In general it may be said that the contributions of the engineer to soil and water conservation may be divided into five segments, namely: (1) Water disposal systems, including terraces, diversions, protected outlets, ponds, and drainage of wet lands; (2) Group water disposal systems, such as outlet drainage, and large gully works; (3) Water utilization, such as land conditioning and water application practices for irrigation, water supply, and water spreading; (4) Group irrigation projects, including the development or improvement of supply and delivery to irrigated farms; and (5) Special engineering works for flood and sediment control, highway erosion control, stream channel improvements, and similar engineering improvements.

The extent of the engineering job to be done as a part of soil- and water-conservation operations on farm and ranch lands can be pointed up, perhaps, by citing the amount of some of them needed on a national basis: farm drainage, 45,000,000 acres; rehabilitation of outlet ditches serving cultivated, or partially cultivated, lands, 31,000,000 acres; community drainage work serving undeveloped lands, 18,000,000 acres; rehabilitation of irrigation works, 11,700,000 acres; outlet and farm water courses, 6,700,000 acres; soil saving dams, 405,000; terracing, 97,000,000 acres.

Perhaps it may serve to clarify the engineering aspects of soil and water conservation if we review briefly some of the more important practices requiring engineering knowledge in a few selected regions of the United States. Let us consider the Northeast, the Southeast, the southern Great Plains, and the Southwest.

Northeast

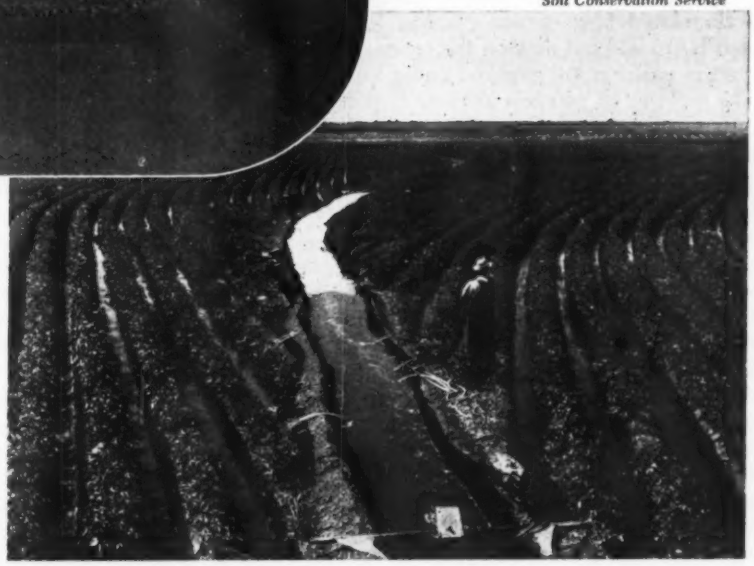
In New England and the nearby northeastern states the rainfall varies from 30 to 50 inches, and there is a growing season of about 130 days. The original vegetation was deciduous or mixed deciduous and coniferous forest, and much of the land is now forested.

Snow covers much of the area in the winter, when erosion is reduced. Spring is a period of floods and se-

◀ SOUTHERN GREAT PLAINS

This badly eroded Oklahoma farmyard, about 20 miles from the Guthrie Soil Conservation Camp, shows a combination of wind- and water-erosion which is not uncommon in the southern Great Plains portion of the United States. As much as 300,000,000 tons of soil were removed from this region during 1934 dust storms.

Soil Conservation Service



Soil Conservation Service

NORTHWEST ▶

Representative of the Northwest is this 40-acre contour irrigated potato field in Fremont County, Idaho, on which effective soil conservation has been carried out. Dams are shortened by head ditches which intersect the field at appropriate distances. Plastic soils are used to irrigate the furrows.

A severe case of soil erosion, extending for about half a mile, occurs at Black River Falls, Wis. The view shown here looks down from the head of the gulley. The extent of erosion may be estimated from the size of the man near the center of the illustration.

Soil Conservation Service

vere erosion. The time of land preparation and planting is the time of maximum exposure to erosion. Another period of erosion occurs in June and July when fields are bare and spring-sown grains afford but a minimum of vegetative protection. During the fall harvest of potatoes, and late truck crops, and during fall plowing for winter grain there is also a critical period. Primarily, erosion in the Northeast is sheet erosion, that is, more or less even removal of soil in thin layers over an entire segment of sloping land. It is the least conspicuous type of erosion, but its effects are nonetheless severe.

Among the needed soil- and water-conservation practices requiring engineering knowledge in this region is contour cultivation in place of the once prevalent up-and-downhill plowing and planting of croplands. Large diversion terraces across crop fields to dispose of excess water are a feature of northeastern soil conservation work. They are required to break the accumulated flow of water across long slopes. Orchards are laid out now on the contour. Contour furrows in pastures are required under some conditions. The building of ponds is likewise important, particularly as a part of pasture management. Water disposal systems for crop fields are valuable. In coastal areas especially, the development of drainage systems is a feature of the land treatment.

Southeast

The Appalachian Piedmont illustrates another broad type of natural area. Here the rainfall is 50 to 60 inches annually. The growing season is twice as long as in the Northeast. Although this country, like the Northeast, was once forested, most of it is now or has at one time been cultivated, three-fourths of which has been devoted to clean-tilled crops like cotton, corn, and tobacco. In this rolling, well-drained region, fields are often exposed to rains throughout the year, and erosion is severe. Gullies, some of them like miniature Grand Canyons, are common.

In this region, gully control has been a measure of rather widespread value. Contour cultivation is generally recommended, and with it extensive terrace systems, together with terrace outlets and grassed waterways to remove excess water. Strip cropping is of value in some places. Farm ponds are common.

Southern Great Plains

This highland area, with the Texas panhandle more or less as its center, is the famous Dust Bowl. The annual precipitation is less than 20 inches, and it is characterized by unpredictable variations, resulting in recurring dry periods, often several years in length. The original vegetation was grass – short or mid grasses much less luxuriant than the tall grasses of the prairies farther east. Here, as throughout the West, the soils are calcareous, in contrast to the acid soils of the humid East. Winds are high and often turbulent. Livestock and wheat are the principal land products. Although sheet and gully erosion occur, the most serious type of land damage is from wind erosion, so severe at times that 300,000,000 tons of soil were blown off the land in a single storm in May, 1934, to be carried across the eastern states, into the Atlantic Ocean.

On cropland in this area, a special type of broad base terrace is used, not to carry water off the land as in the eastern humid areas, but to spread it and permit it to sink into the soil. These terraces may be 40 feet wide at the base with a very low crown. They follow the gentle contour of the land, may be miles long, and are usually closed at the ends. Strip cropping is used, primarily for wind erosion control. Contour cultivation and contour listing are practiced. On the pastured lands in the Plains, contour furrows are sometimes used, and ponds are frequently constructed.

Southwest

In the arid portions of Arizona, New Mexico, and adjacent states, the rainfall is nowhere more than 14 inches, except in the mountains, and in some parts of

Contour strip farming in Northumberland County, Stone Valley, Dalmatia, Pa., presents an interesting and striking view from the air, quite aside from the economic value to be gained by such soil conservation measures when applied to rolling country such as this.

Soil Conservation Service

these states precipitation may average only a couple of inches per year. These are desert areas, or at one time, before the white man came, they were perhaps desert grasslands. Grass is found now only in sheltered spots not accessible to grazing livestock. Water erosion is the cause of soil loss in much of this region. Siltation of streams and sedimentation of reservoirs are serious. The Southwest has been livestock country, and soil conservation on depleted ranges is a tremendous problem.

In order to make the best use of existing forage, and to use the prevailing rainfall to its maximum, various land treatments requiring engineering knowledge on range lands have been utilized. Water spreading is such a practice. This may consist of small ditches that divert water from gully heads, or be a more complex system of channels to spread rainfall over extensive areas. Water retention structures of various types may be used in connection with such systems. Contour furrows are used as in other types of grazing land. Structures, some of them rather large ones, are frequently used to control head cutting of gullies.

Throughout the arid Southwest, as in many other sections of the United States west of the 100th meridian, river flood plains and river benches are now used extensively for the growing of cultivated crops. Cotton, alfalfa, fruit, truck, beets, grain, and a variety of other crops are grown in irrigated valleys of the West. Reclamation of western land for irrigation is a tremendous engineering task. The construction of water storage impoundments, some of them gigantic, river diversions, and main and lateral canals all require consummate engineering skill. When the water finally reaches the farm land itself it must be most carefully used, if soil and water conservation is to be achieved. Water must be carefully supplied to fields by appropriate channels, and gently deployed over the field itself. Ditches to provide the water and to carry away excess must be well engineered. To make the best use of water, most irrigated fields in the West are now being leveled with the use of heavy equipment before a crop is grown.

Engineering as Part of Soil Conservation

In the above regional examples, only soil- and water-conservation practices that require engineering principles and knowledge for their correct design and application have been mentioned. These practices are only a part of the job. This point should be stressed, for soil conservation is a synthesis of sciences.

Wherever soil conservation is to be accomplished, there must first of all be a blueprint of land use prepared by a soil scientist and others. This consists of the land capability map of the operating unit of land, together with recommended treatments for each kind of land. The first requirement of a land operator who wishes to manage his land according to its physical capabilities, is to make sure that use of the land is in accordance with its capabilities. If it is not, then land-use conversions are required.

On crop fields, terraces and water disposal systems, however well designed, are worse than useless if they are applied to land that should not be cultivated. Land leveling and expensive irrigation systems are of no avail, no matter how well conceived, if they apply to soil that will not grow crops for an indefinite period of time. The same can be said of every other engineering practice useful in soil- and water-conservation work. It is useful only if it is applied, along with other practices, to land whose capability permits the kind of use the engineering practices are intended to support. The land use must first be right.

On most land best suited for crops, getting a cover of vegetation and incorporating more and more humus into the soil are of first importance. Thus it is that green manuring, cover crops, crop rotations, and crop residue management are soil conservation practices of primary value for cultivated land. In meadows and pastures the selection of the most appropriate grasses and legumes, correct seeding and fertilizing,

Soil Conservation Service

A good example of erosion of soil on pasture and range lands in Iowa, due to overgrazing, is illustrated here.

together with rotation and deferred grazing, are important. On range land of the West and in wood lots, too, there are many special practices that contribute to the best use of each type of land at the same time that erosion is controlled and the soil preserved. There are more than 50 specific soil- and water-conservation practices. With each of the types of land use the engineer can contribute immeasurably. The land, in fact, cannot be well managed without his specialized knowledge and techniques. But the engineer is just one of a team. It is only when he works with the soil scientist, agronomist, forester, biologist, range manager, and other land technicians that he can make his greatest contribution to soil conservation.

Working with Nature

A simple example will serve to illustrate. In the early days of soil conservation work, terrace outlet channels were frequently designed to include a series of masonry drop structures. These were not only expensive, they often interfered with the use of farm machinery. Working with the agronomist and soil scientist, the engineer learned after awhile that certain kinds of grasses could be successfully seeded on terrace outlets. If the outlet was constructed a year or two before water from the terraces was discharged into it, the grasses had time to form a thick sod. Then when water from the terraecs did flow down the outlet, structures were often unnecessary, if permissible velocities were not exceeded. In the Soil Conservation Service it is not unusual to hear engineers talking about *Poa pratensis* or *Bromus inermis* as if their training had been in agronomy where the Latin names of plants are tools of the trade. Conversely, other technicians have picked up some of the simple engineering tricks of the trade.

It is only fair to state that conservationists probably fling more criticism at engineers than at any other group of technicians. Whether these conservationists are interested in forests, grazing lands, wild life, water pollution control, soil conservation, or some other particular phase of conservation, there is often expressed the idea that there is something incompatible between engineers and conservationists.

This attitude is especially directed against engineers who design large water impoundments that are often publicized as conservation projects. Conservationists are quick to point out that huge dams often flood great acreages of valuable agricultural land, destroy unique waterfowl habitat, or are built to irrigate land that is inherently poor for cultivation. Where engineering projects drain swamps and marshlands, the objection has been frequently heard that such activity destroys natural conditions for muskrats and waterfowl worth more per acre than any other product of such land. It is no secret that in the United States we have, during our short history, drained much wet land that was not fit for cultivated crops after the drainage was completed. Stream straightening, water-course diversion, and other engineering activities have drawn the fire of conservationists at times.

Like most generalizations, of course, it is foolish to think of engineers *versus* conservationists. Many engineers are top-notch conservationists. Our discussion points up once more, however, the necessity of looking at the whole job to be done. In the past, many engineering works have been considered to be conquests of nature. In conservation work at least, where we are dealing with soil, water, and the other components of our natural environment, we do not conquer nature, we learn to work with her. Even such an engineering achievement as Hoover Dam is less striking if, as Colonel Claude H. Birdseye predicts, it will be filled with silt in 144 years.

One of the fundamental laws of nature is that all parts of the environment are related. An engineer would not design a dam, or bridge, or tower, without relating all members of the structure to each other, or without considering it in relation to the earth upon which it is to stand, or without weighing its appearance against its purpose. It is but an extension of this type of reasoning to a fuller understanding of the natural world in which we live.

Permit me to cite an example of interrelationships in nature from my own field of biology. A farmer once complained that he no longer had ducks on his pond. A biologist determined that there were ducks no more because the skunks were being trapped. This seemed a poor explanation until the biologist explained that skunks dig snapping turtle eggs out of the sand where they are laid, and eat them. When the skunks were trapped, the turtles multiplied until their food became scarce. Then the turtles began to feed on ducklings. The ducks would not nest where they were thus molested, and they left. Thus the relationship between the ducks and the skunks. This story is often used as an example of ecological thinking, that is, thinking not so much in strict terms of cause and effect, but in terms of interrelationships.

(*Continued on page 304*)

THRUST PROBLEMS IN Damaged Arch Bridges

The Experience of Army Engineers in Repairing War-Damaged European Bridges Emphasizes Some Novel Methods of Reconstruction

By **WERNER H. GUMPERTZ**

MULTIPLE arch bridges are usually designed in such a way that the horizontal components of the arch thrusts of two adjoining arches cancel each other at the piers. Thus, the piers have to absorb only the resulting vertical forces, or forces very close to the vertical in case of unequal arch spans. The wholesale destruction of European bridges during World War II has given engineers an opportunity to observe the effects of horizontal arch thrust, when the balance of the bridge has been disturbed by the destruction of one or more arches. The observation of the remaining arches has led to further studies regarding the solution of the thrust problem in varying local conditions. Certain experiences with combined masonry and steel structures in the mountains of Switzerland and Austria have shown how these problems were solved in the period after World War I.

Results of the blasting of one or more spans of multiple arch bridges have been manifold, according to the particular design. Reinforced concrete structures have usually fared best, since they have a great reserve strength, and, to some extent, can absorb the change from compression to tension in certain essential sections. If, for example, the center span of a multiple reinforced concrete arch bridge has been destroyed, the arch thrust in the last remaining arch will exert a horizontal force on the head of the last pier. This force will be counteracted by the tensile strength of the steel in the arch crown. In case of a masonry or plain concrete structure there is no steel in the crown, and the tensile strength of the arch is therefore very small. In both cases it must be assumed of course that the arches are fixed. As the horizontal force increases, it will materially affect the pier that, by virtue of the blasting, has now become the last standing pier. The resultant force in that pier, which before had safely been absorbed by the pier foundation, will be deflected toward the gap. Once the small cohesive force between the pier and its foundation is overcome, the pier will inevitably collapse, causing one or several adjoining arches to collapse with it.

Experience has shown that some plain concrete and masonry arches, usually with half-circular intrados, have retained a precarious balance without collapsing. It should be borne in mind, however, that concrete and masonry arches never quite stop "working," and the influence of plastic flow is now generally recognized. In many cases the complete collapse of the bridge can be prevented, therefore, by prompt action in counteracting the one-sided arch thrust. A number of countermeasures have been taken, adapted to the particular local conditions to insure the preservation of partly destroyed bridges. In the following, a few of these measures will be shortly discussed.

A viaduct with small spans, only one of which has been destroyed, is shown in Fig. 1. The simple and effective emergency repair, in which the two piers are braced against each other, creates a safe bridge, for the thrusts from both sides are balanced. The flow of forces in the piers was not materially changed. A simple beam across the top carried the traffic. No further action was required until such time as permanent repairs could be made.

An article in the *Engineering News-Record*[1] describes how one arch of a demolished Italian viaduct was closed by erection of a filling wall which counter-

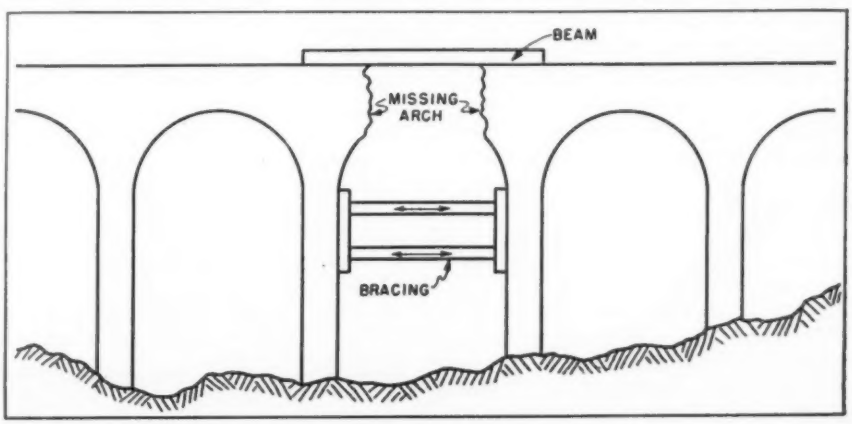


Fig. 1. In those cases in which a single arch has been destroyed, emergency bracing in the arch opening, with beams above the break, provides effective temporary reconstruction.

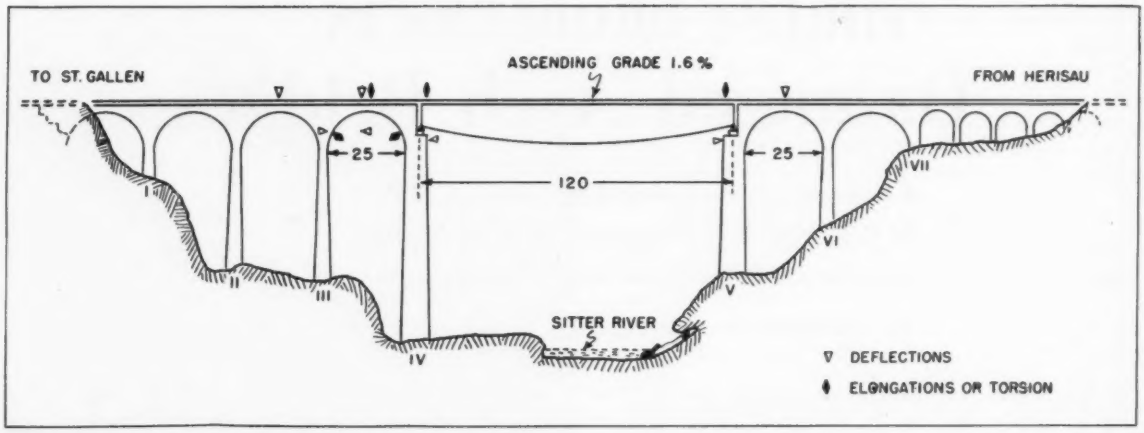


Fig. 2. Diagram of arched bridge between St. Gallen and Herisau, Switzerland, before damage of central arches. The great height of Pier IV, more than 300 feet, made repair a difficult task. All dimensions are in meters. Positions of tensiometers are indicated in the diagram.

acted the pressure from an adjoining earth embankment. To prevent arch thrust, a similar solution has been proposed by Mr. Bleich in *Schweizerische Bauzeitung*[2] (Zurich, Switzerland). In this case, the viaduct had not been destroyed by blasting. It consisted of a steel center section and masonry arch approaches as shown in Fig. 2. Since the steel span was supported as a simple beam, it contributed nothing to the bracing of the two masonry approaches. The one-sided thrust soon showed itself in the deflection of the masonry pier heads. The bearings of the steel span had to be readjusted because the two end piers were being deflected towards the gap. Shortly before World War I, the deflection had become so great that decisive measures had to be taken, and it was proposed to fill the two end arches with masonry, thus creating a stable base which could absorb the one-sided thrust. War events intervened, and the subsequent electrification of the railroad line crossing the viaduct made it necessary to build a new structure. However, an important lesson was learned, and from then on no important bridge was built with two different basic materials, that is, masonry (or concrete) and steel.

The Castle Muir Bridge in Switzerland crosses a mountain stream on several small arches. When a flash flood washed out one of the river piers, the two adjoining arches collapsed. They were replaced by erection of a single reinforced concrete arch. The new

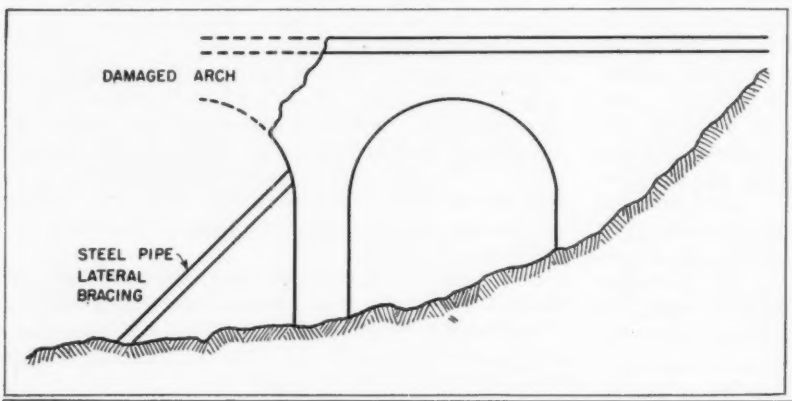
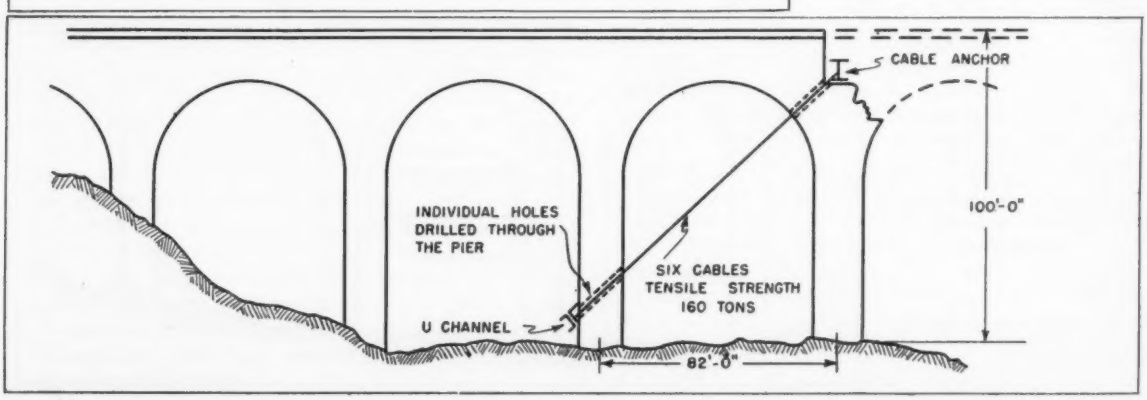


Fig. 3. East end of Kaempfelbach viaduct, after war damage, is braced with four parallel steel pipes whose purpose is to conduct side thrust on remaining arch safely to ground, as shown at left.

Fig. 4. Sketch (below) *of the "tie-back" arrangement at the west end of the Kaempfelbach viaduct. The unbalanced side thrust of the last pier, which has not been destroyed, is anchored by the six cables connecting the cable anchor with the U-channel.*



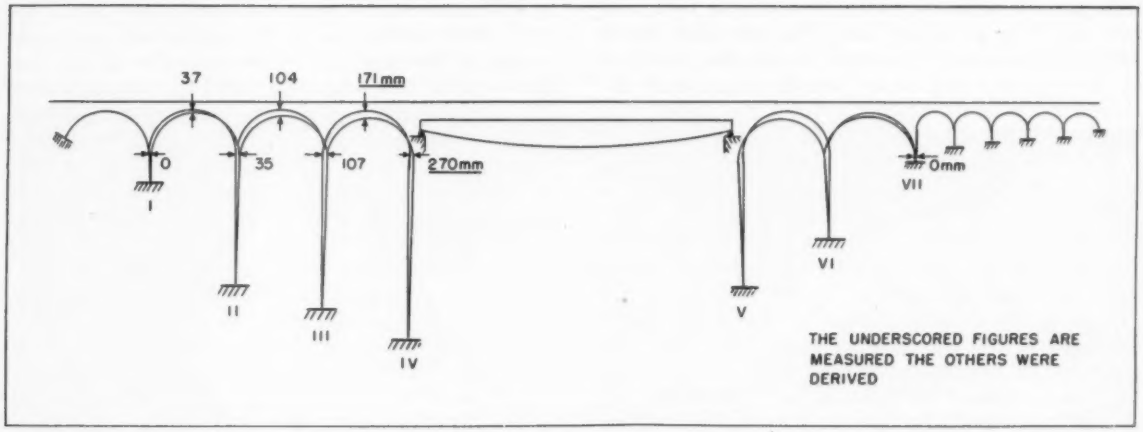


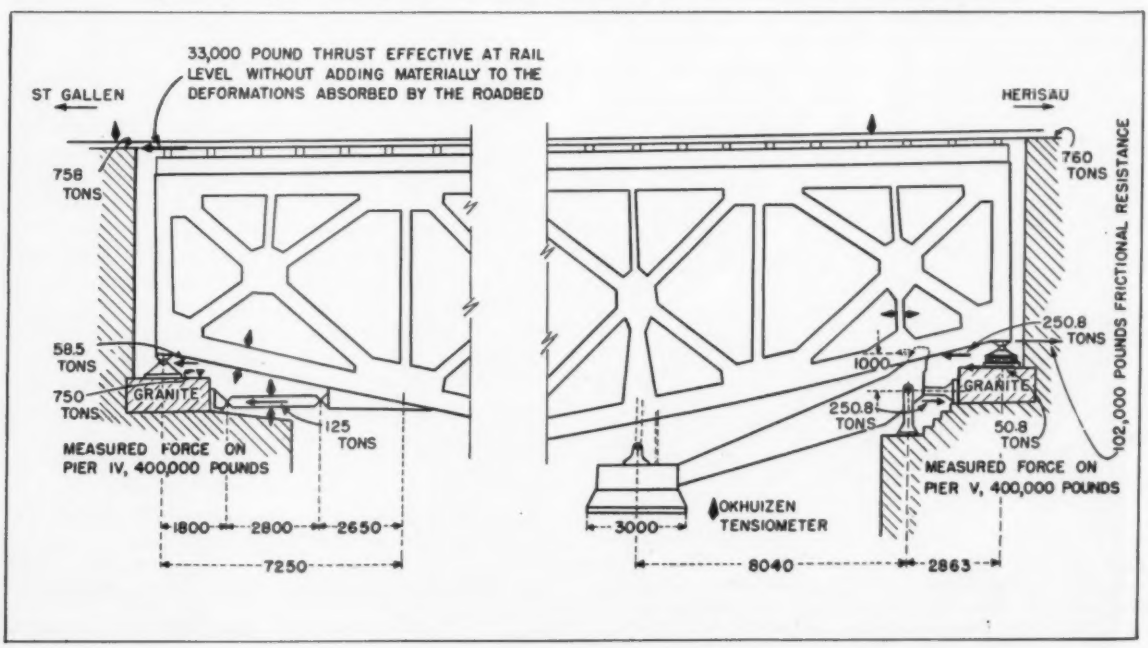
Fig. 5. Diagram showing the positions of the piers before and after war damage of the Swiss viaduct between St. Gallen and Herisau. The deflections of the pier and arch crown are given here in millimeters. The original position of the arches is shown for purposes of comparison.

span absorbed the thrust from both sides, and no further difficulty was encountered with this bridge.

Two interesting semipermanent solutions were found in the reconstruction of the partially destroyed Kaempfelbach viaduct near Pforzheim, Germany, on the superhighway between Frankfurt and Munich. Eight of the 13 concrete arches had been demolished by retreating German forces. The length of the gap was 672 feet, and the roadway was up to 190 feet above the bottom of the valley. The east end of the viaduct as shown in Fig. 3 was not too high, so that the lever action of the thrust was not excessively great. Structural steel pipe of heavy cross section was employed as lateral bracing, being placed against the pier at about half height, and resting on the ground at an angle of 45 degrees. Any one-sided thrust could thus safely be conducted through the pipe to ground, without causing the pier to tip over.

Most of the piers on the west side were much higher – about 100 feet – and braces could not be employed. Therefore it was decided to anchor this pier with the help of steel cables to the next adjoining pier, as shown in Fig. 4. An I beam was placed across the width of the pier as a cable anchor, and the pier itself was pierced by six accurately drilled holes. Steel cables of 165 tons tensile strength each were carried through the holes and anchored to the I beam at even distances. Similar holes were drilled near the bottom of the next adjoining pier, and the cables were similarly anchored in a U-channel leaning on the back of that pier. These holes were drilled with great precision to avoid any contact between the cables and the con-

Fig. 6. Both ends of the steel truss of the St. Gallen-Herisau viaduct are shown with the counterthrust lever in place. Note the special bearings to transmit the thrust force horizontally. Measurements are given in millimeters.



crete piers. Finally the cables were evenly tightened with the help of turnbuckles. The one-sided thrust which had threatened the structure was thus absorbed by the tension in the cables, and the cables were anchored so low on the adjoining pier that no substantial bending moments occurred there.

It was now possible to proceed with the reconstruction of the viaduct. Due to material shortages, SKR (Shaper-Krupp-Reichsbahn) steel trusses were employed. These trusses[3] were readily available from captured German army stocks. The solutions which had been adopted to take care of thrust at the ends of the remaining arches, however, did not appear quite satisfactory. The pipe bracing at the east end is subject to settling in the ground due to the pressure, and the cables on the west end, not easily adjustable, required permanent supervision and maintenance. Temperature changes might cause such variations in cable length as to give the I beam on top of the pier considerable leeway, thus causing plastic flow in the concrete arch, so that the stability of the structure might again be endangered. There was also some danger of possible serious damage due to tampering with the easily accessible cables.

Past experience with a problem of such special nature is, of course, very limited. No similar case in American bridge engineering could be found by the writer of this article. However, Swiss engineers had been faced with a problem almost identical with that of the Austrian viaduct described above. The solution appeared to be so interesting and applicable in this case that it will be described below as a possible final measure to secure the concrete structure of the Kaempfelbach Bridge.

Reference is made to two articles in the *Schweizerische Bauzeitung*.[4] In the second article, Professor M. Roš of the Swiss Federal Institute of Technology in Zurich describes the Sitter River viaduct of the Bodensee-Toggenburg railroad in Switzerland. As in the case of the Austrian bridge, this viaduct consists of high masonry approaches and a center steel truss 400 feet long, as in Figs. 2 and 5. Since the erection of the bridge in 1909, the one-sided arch thrust had caused a considerable deflection of the two river piers which, by 1921, amounted to 11 inches in one of the piers. Figure 5 shows deflections of the various piers and arch crowns of the structure before corrective action was taken. At the time when this viaduct was examined in 1921, the phenomena of plastic flow were not too well known, but extensive test measurements gave a good picture of the manner in which the structure reacted, including pier deflections, deflections of the arch crowns, and the appearance of cracks in the arches. Since the steel truss was supported as a simple beam, it did not help to counteract the thrust from both sides. Professor Roš, therefore, decided to create an artificial counterthrust and to transmit this thrust axially through the steel truss in both directions — a solution both ingenious and simple. It was accomplished by installing a counterthrust lever at the roller bearing end of the steel span, using the common lever principle.

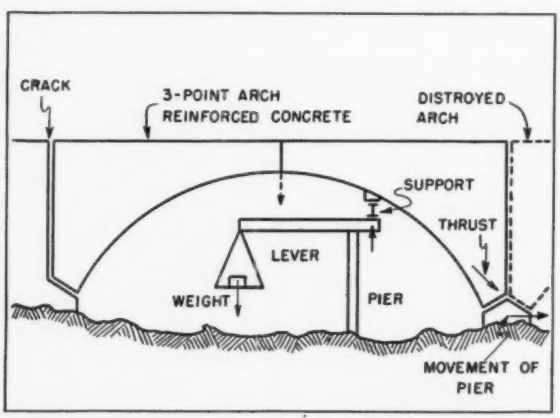


Fig. 7. The right-hand pier of this three-point arch bridge moves under the influence of the one-sided thrust. Sketch shows the temporary support of the arch, using the principle of the lever in providing support.

As shown in Fig. 6, the free arm of the lever was weighted down by a steel weight, and the other arm had two stiffly connected levers, one of which rested against the arch structure, the other lever transmitting the counterthrust into the steel truss and eventually through the rails and a special horizontal bearing into the other end of the masonry arch structure. As the weighted arm of the lever was freely suspended, any change in the length of the steel truss could be absorbed by a slight upward or downward movement of this arm. No change in the magnitude of the horizontal counterthrust would be caused by this motion. Temperature changes, traffic and impact loads, as well as changes in the length of the steel truss could thus be absorbed. No adjustment was necessary, and the lever was far removed from any possible interference.

The counterthrust was initially set at 250 tons. An increase or decrease could be effected by adding or removing weight from the free arm of the counterthrust lever. Actually, the thrust force of 250 tons proved to be of proper magnitude, and in the year following the installation of the counterthrust lever, the original deflection of the high stone piers was reduced considerably. The cracks in the arches were grouted, and the entire structure is now completely sound, and, with the continued use of the lever, requires no further adjustment.

In applying the above principle of a counterthrust lever to the case of the Kaempfelbach viaduct, it should be noted that most conditions are very similar in both cases. As a first approximation, the magnitude of the necessary counterthrust could be estimated to be 200 tons. Should later tests show that a greater force was required to hold the movement of the arches, adjustment could be made easily. The steel span of the German SKR bridge is longer than that of the Sitter viaduct — 672 feet as compared to 400 feet — and a rough calculation would show whether the structure is safe against buckling when an axial pressure of 200 tons is applied.

For the purpose of this approximate computation, the whole steel span is considered as an axially loaded column, with both ends unrestrained. The weight of the span itself would prevent upward buckling, while downward buckling would be prevented by the three intermediate piers. Between these piers, the bridge is

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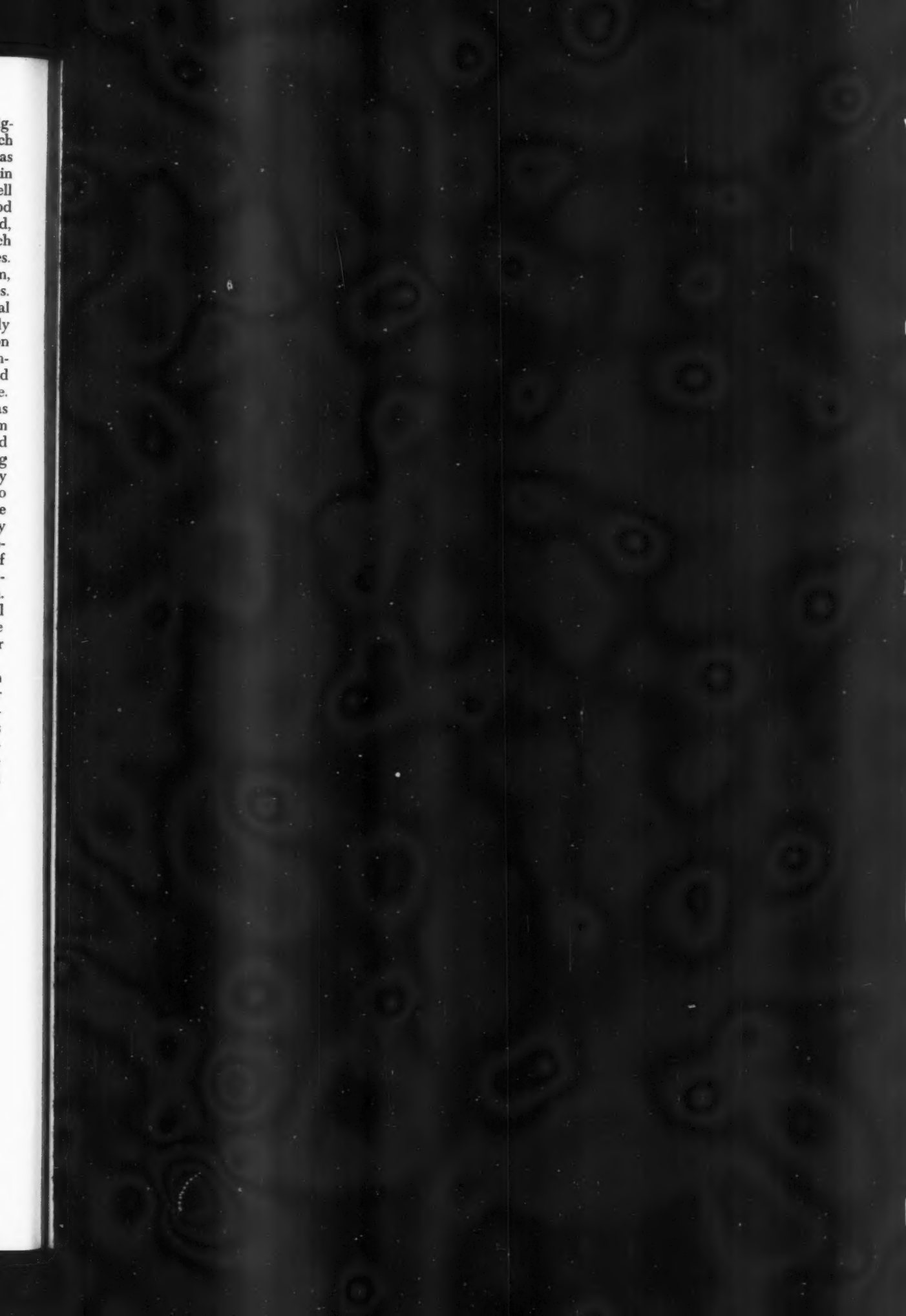

Architectural Acoustics—

New Trends in Teaching and Research

Modern Architectural Acoustics Combines Several Sciences and Emphasizes Human Welfare and Comfort

By **R. H. BOLT** *and* **A. M. CLARKE**

AWARENESS of the acoustical quality of rooms goes as far back as the Roman civilization, but literally nothing was attempted in the way of designing rooms that were acoustically good until the turn of the Twentieth Century. Throughout the intervening centuries, attention was paid to this problem, but the emphasis was placed primarily on advancing the theory of sound rather than on developing and applying acoustic principles for more effective and comfortable appreciation of sound. About half a century ago, the late Professor Wallace C. Sabine, of Harvard University, was the first to make a concerted effort to find the reason why one room was acoustically better than another. By means of innumerable painstaking experiments, he arrived at an approximate analysis of the reverberation of sound in rooms, that is, the repeated "echoing" of sound from room walls with decreasing intensity until quiet is reached. Sabine's formula for reverberation time – the time for the sound intensity level to decay to 10^{-6} of its steady value – was empirically developed, but his results were subsequently substantiated by theoretical considerations, and formed a stepping stone to present-day room acoustics. Research continued to be sporadic, however, and for the most part was carried on by individual effort. Then, in the 1920's, there was sufficient stimulus to bring the study of architectural acoustics into focus as an integrated science.

The advent of radio broadcasting and of motion pictures with sound posed new problems in acoustical engineering. The founding of the Acoustical Society of America in 1929 provided the much needed meeting of minds and correlation of ideas; and advances in electronic technique and equipment design opened up new methods of study by providing highly effective and flexible measuring techniques. Notable progress in wave mechanics and applied mathematics advanced acoustic theory. The application of the mathematics of atomic physics to the theory of sound yielded a new approach to room acoustics.

Since that time, the necessity for combining good architecture with good acoustics has received more and more attention from many sources. Perhaps the greatest single drawback has been the lack of men qualified in both acoustical science and architecture. In time, of course, this lack will be rectified, but so far the process has been a slow one and it is only with the increasing appreciation of the importance of this subject, and the training of qualified men in the field, that the process will be speeded up.

The broad field of acoustics, and especially that of architectural acoustics, offers a particularly rich and fertile field for the advancement of research and teaching methods, and the further development of the mature student to meet the needs of modern society. First of all, the student's interest and enthusiasm may be easily aroused, for the field of applied acoustics is a comparatively new one. Much fundamental work still remains to be done in it, so that those now entering this field, or those already engaged in it, have the prospect of doing pioneering and fundamental work. This appears to be particularly true in the engineering rather than the pure science aspects of the subject. In its applications, architectural acoustics offers many opportunities for promoting human comfort and welfare. The student and research worker are brought into direct contact with such subjects as architecture, mathematical physics, engineering, economics, psychology, and are concerned with aesthetic and cultural problems which usually are not brought out quite so significantly in other branches of engineering.

Recognizing the opportunity for carrying on useful research, and for conducting pioneering educational methods in this important field, M.I.T. expanded its undergraduate and graduate program of courses in acoustics and established the Acoustics Laboratory in 1946. This laboratory is administered jointly by the School of Architecture and the Departments of Electrical Engineering and Physics. These three Departments give a total of nine courses that cover various aspects of acoustics and are designed to provide a broad co-ordinated training in this field. Of particular interest is the graduate course in architectural acoustics which is given jointly by the director of the Acoustics Laboratory and the head of the School of Architecture. It is a project-basis course in which the students are given one major problem to be worked out over a period of several semesters. The original group of students in the course were given a problem in studio research.

This project constituted the first and implementing portion of the long-range program in room acoustics, aimed toward providing an integrated study extending over a period of several years. The program is divided into three general stages: (1) the design and construction of an experimental studio suitable for sound recording and radio broadcasting; (2) comprehensive physical testing of acoustic performance by both standard and newly developed methods; (3) in-

The control room is separated from the acoustic chamber by a double-pane window which enables operators to have visual contact but aural isolation from events in the studio.

vestigation of speech articulation, listener reaction, and other subjective aspects of room acoustics. The studio development provided an adequate means of carrying out the program since it illustrates most of the problems of room acoustics, and, in addition, it facilitates a wide range of tests and has a basic practical value.

Both the program and the student project were in the nature of an educational experiment, since they offered not only something comparatively new to students but also called for integration of several points of view and sustained co-operation on the part of several academic departments. Eight graduate students from various parts of the country were originally enrolled in the architectural acoustics course. The problem assigned was, in part, as follows: "In line with the long range planning for the Institute, it is desirable to explore new possibilities in the design of studios for recording and broadcasting. It is the purpose of this problem to design a studio which can be erected during the spring term. This studio would then be subjected to a wide variety of acoustical measurements and performance tests as part of the general research program."

After a review in the fundamentals of sound, trends in applied design of studios were studied. Several class members then produced original designs and small scale models of proposed studios. On the whole these showed good planning, and presented some interesting new contributions of interior design and acoustic engineering. The design selected for full-scale construction was a composite of the best work of the group as a whole, and this was reduced to detailed working drawings by the students. The students had the considerable advantage of seeing their ideas put into concrete form. By actually supervising the construction they were made conscious of the importance of acoustical quality as a fundamental element in the design of any room.

The requisites for a room or studio that is acoustically good can be predetermined up to a certain point with but a fair amount of exactness. General empirical knowledge and proven mathematical theory supply a good deal of the basic groundwork, as indeed they should. As yet, however, acoustical engineering has not attained the degree of precision and reliability which characterizes most fields of engineering; it is hoped that the work now in progress can make a contribution in putting architectural acoustics on a firmer engineering basis.

Objective Measurements of Studio Performance

The second step in the comprehensive program now under way is the determination of the physical properties of the studio and the correlation of its measured properties with those ascertained by existing theory and empirical knowledge. Since no two rooms are exactly alike, it would, of course, be expected that the results of measurements made on a single studio would be of limited value in developing a broad, comprehensive understanding of acoustical engineering principles. To a certain extent this is true. At the same time, it is possible to obtain a vast amount of

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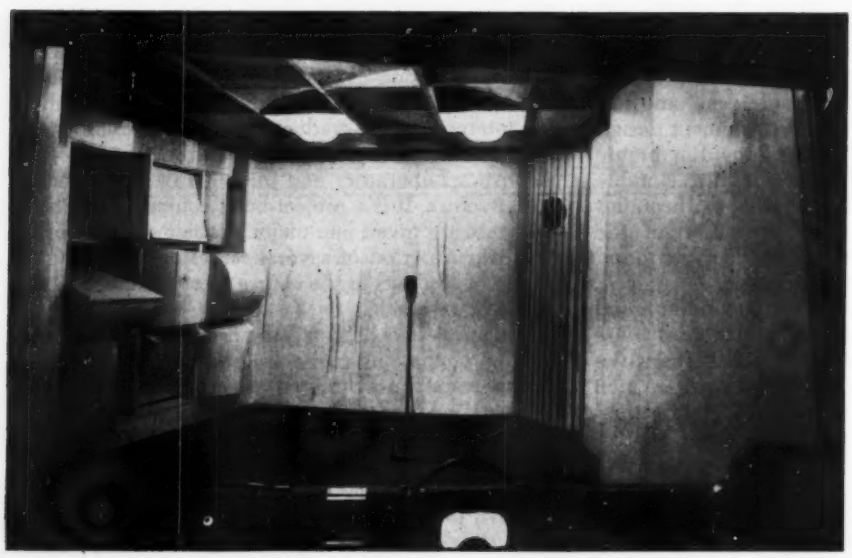


The view from the control-room window illustrates the unusual construction of the studio which provides the flexibility required by research. The semicylinders at the left may be turned to present flat or rounded surfaces with axes alternately vertical and horizontal. The ceiling is divided into cells, each with its slope different from that of adjacent cells. At the right, the walls are curved, in further attempt to provide sound diffusion and minimize standing waves. All wall surfaces and ceiling sections are demountable, replaceable units. Sound may be introduced by the loud speaker shown as the dark circle beyond the vertical grill.

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

Inauguration of James Rhyne Killian, Jr. as the Institute's Tenth President to Culminate Cambridge Celebration

CLIMAXING an international mid-century convocation on the social implications of scientific progress to be held at M.I.T. on March 31 and April 1, will be the inauguration of Dr. James R. Killian, Jr., '26, on April 2 as the Institute's tenth president. President Harry S. Truman and the Right Honorable Winston Churchill, both of whom will deliver addresses, will be among the group of distinguished statesmen, educators, and scientists coming to Cambridge from all over the world to participate in the convocation and inauguration. Those who have already accepted invitations to take part in the convocation panel discussions are listed in the table below.

The convocation will open on the afternoon of Thursday, March 31, with an address by Professor John E. Burchard, '23, Dean of Humanities at M.I.T. and chairman of the convocation; and Dr. Karl T. Compton, chairman of the M.I.T. Corporation and chairman of the Research and Development Board of the National Military Establishment, will sound the keynote of the convocation in an address on "The State of Science."

In the evening, Mr. Churchill will deliver an address on the general theme of progress realized during the Twentieth Century. On Friday, April 1, the second day of the convocation, there will be six panel discussions, the first of which will consider "Men against Nature . . . .The Problem of World Production." This will be the first of two panels on material questions; and the second, on Friday afternoon, will consider "Men against Men . . . The Problem of the Underdeveloped Area." There will be two panels on spiritual questions: the first "Science, Materialism, and the Human Spirit"; and the second "The Role of the Individual in a World of Institutions."

Intellectual questions will be covered in two further panels, the first of which will consider "Specialization in Twentieth Century Education," and the second, "The State, Industry, and the University."

President Truman will deliver his address on Friday evening, April 1. It is hoped he will deal with the contributions which science and technology can be expected to make to the nation's welfare.

The ceremonies at which Dr. Killian will be inaugurated will be held in the new Rockwell Cage at the Institute at 11:00 A.M., Saturday, April 2. Dr. Compton, whom the new president will succeed, will introduce Dr. Killian and invest him with the authority of his office as tenth president of M.I.T. The academic delegates and Harvard University will be represented by James Bryant Conant, President of the University, who will make an address at the inauguration ceremonies. John T. Toohy, President of the M.I.T. Class of 1949, will address the new president in behalf of the Institute's student body, and the Alumni will be represented in an address by David A. Shepard of London, a member of the Class of 1926 with which Dr. Killian was graduated. The Faculty will be represented by George R. Harrison, Dean of Science, whose address will close the inauguration ceremonies.

INVITED GUESTS WHO WILL PARTICIPATE IN CONVOCATION PROGRAM

OSWALDO ARANHA — formerly, Brazilian Ambassador to United States
JAMES M. BARKER, '07 — Chairman of Board, Allstate Insurance Company
LAIRD BELL — Vice-Chairman of the Board of Trustees, University of Chicago; Chairman of the Board of Trustees, Carleton College
RICHARD M. BISSELL, JR. — Professor of Economics, M.I.T., on leave as Assistant Deputy Administrator, Economic Co-operation Administration
JULIUS SEELYE BIXLER — President, Colby College
PERCY W. BRIDGMAN — Hollis Professor of Mathematics and Natural Science, Harvard University; Nobel Prize in Physics
VANNEVAR BUSH, '16 — President, Carnegie Institution of Washington
ERWIN D. CANHAM — Editor, *The Christian Science Monitor*; President, American Society of Newspaper Editors
CARLOS CONTRERAS — Architect, Mexico City; President, National Planning Association of Mexico
LEE A. DUBRIDGE — President, California Institute of Technology
RALPH E. FLANDERS — United States Senator from Vermont
CLINTON S. GOLDEN — formerly, Vice-Chairman, War Production Board, War Manpower Commission; now, Labor Adviser, Economic Co-operation Administration
WILLIAM MALCOLM HAILEY — Baron of Shahpur in the Punjab and Newport Pagnell in Buckinghamshire; Member, House of Lords
SIDNEY HOOK — Chairman, Department of Philosophy, New York University
BRYN J. HOVDE — President, The New School for Social Research
FREDERIC LILGE — Assistant Professor of Education, the University of California; author, *The Abuse of Learning*
SIR RICHARD LIVINGSTON — formerly, Vice-Chancellor of Oxford; now, President, Corpus Christi College, Oxford
JACQUES MARITAIN — formerly, French Ambassador to the Vatican; Professor of Philosophy, Princeton University
SIR RAMASWAMI MUDALIAR — President, United Nations Economic and Social Council, Prime Minister of Mysore State, India
FRANK W. NOTESTEIN — Professor of Demography, Princeton University and Director of Office of Population Research in the Woodrow Wilson School of Public and International Affairs
PETER H. ODEGARD — Chairman, Department of Political Science, University of California
FAIRFIELD OSBORN — President, the New York Zoological Society; author "Our Plundered Planet"
ANDREY A. POTTER, '03 — Dean of the Schools of Engineering and Director of the Engineering Experiment Station, Purdue University
NELSON A. ROCKEFELLER — President, American International Association for Economic and Social Development; President, International Basic Economy Corporation; one-time Assistant Secretary of State
PHILLIP J. RULON — Professor of Education, Harvard University
JOHN DALE RUSSELL — formerly, Professor of Education, University of Chicago; Director, Division of Higher Education, United States Office of Education
ROBERT P. RUSSELL, '22 — with International Basic Economy Corporation in Venezuela
PIERRE RYCKMANS — formerly, Governor General of the Belgian Congo; now, Belgian representative on the Trusteeship Council, United Nations
WALTER T. STACE — Stuart Professor of Philosophy, Princeton University
CHARLES A. THOMAS, '24 — Executive Vice-president, Monsanto Chemical Company
SIR HENRY TIZARD — formerly, President Magdalen College, Oxford; Chairman, Defence Research Policy Committee of the Ministry of Defence, United Kingdom
MERLE A. TUVE — Director, Department of Terrestrial Magnetism, Carnegie Institution of Washington

Supersonic Tunnel

JOHN A. LUNN, '17, Vice-president, presided at the 266th meeting of the Alumni Council in the Graduate House on January 31, in the unavoidable absence of C. George Dandrow, '22, President. In spite of inclement weather, 67 members and guests were in attendance. During the business portion of the meeting it was announced that nine members of the Institute's staff visited 17 M.I.T. clubs from Worcester to San Francisco during December and January; that the number of contributors to the Alumni Fund is running ahead of that for the corresponding period last year, but is lagging in amount. Nominees for election by the Alumni Association, as recorded in the following columns, were also announced, as were the chairmen of committees for Alumni Day, 1949.

Everett M. Baker, Dean of Students, summarized plans for the presidential inauguration of Dr. Killian in the Rockwell Athletic Cage on April 2. Housing of guests is likely to present a problem during the inauguration and convocation ceremonies, and it is anticipated that the new Senior House will be used to alleviate any overcrowded conditions which may arise. The inauguration will climax a three-day celebration at the Institute, of which the first two days will be devoted to a discussion of the social implications of modern science.

Mr. Lunn then introduced Professor John R. Markham, '18, of the Aeronautical Engineering Department, and Director of the Institute's supersonic wind tunnel which is nearing completion in a new building on M.I.T. property west of the main buildings and near the Cottage Farm Bridge. With the aid of slides, Professor Markham discussed the design of supersonic tunnels in which wind velocities exceeding the speed of propagation of sound are produced for modern aeronautical research. Particular emphasis was given to the problems of producing wind velocities of several hundred miles per hour, cooling of the tunnel, minimizing sound and vibration, eliminating moisture in the tunnel, supporting models within the tunnel, and of making measurements by mechanical and photographic methods.

Democracy's Prerogative

MARCH is the month in which ballots go to M.I.T. Alumni for their annual election of officers and representatives of the Institute's 40,000 Alumni. C. Adrian Sawyer, Jr., '02, III, President of the Sawyer Construction Company, has been nominated for the presidency of the M.I.T. Alumni Association for the year beginning July 1, 1949.

The Association's National Nominating Committee – with Robert S. Williams, '02, chairman, Ralph C. Robinson, '01, Gordon G. Holbrook, '10, Jonathan A. Noyes, '12, Robert C. Erb, '17, Minot R. Edwards, '22, John S. Williams, Jr., '22, Henry C. Gunning, '26, Thomas G. Harvey, '28, and Stephen L. Macdonald, '39 – has also nominated for election to the vice-presidency for a two-year term Horatio L. Bond, '23, XV, chief engineer, National Fire Protection Association, Boston. Philip E. Morrill, '14, I, Vice-president and Director, Bemis Bro. Bag Company, Boston, and Parke D. Appel, '22, VI, general personnel assistant, New England Tel. and Tel. Company, Boston, have been nominated to serve on the M.I.T. Alumni Association's Executive Committee for terms of two years each, beginning July 1, 1949.

Nominated for alumni term membership on the M.I.T. Corporation for five-year terms are: Robert T. Haslam, '11, X, Vice-president and Director, Standard Oil Company (N.J.), and Director and member of the executive committee of the Ethyl Corporation; Rudolf F. Haffenreffer, '95, chairman of the board, Narragansett Brewing Company; and George J. Leness, '26, I, partner of Merrill Lynch, Pierce, Fenner and

TO THE PRESIDENCY

. . . of the Alumni Association, C. Adrian Sawyer, Jr., '02, has been nominated for election for the coming year. Following his graduation from the Institute, Mr. Sawyer was an assistant in the Department of Mining Engineering for a year. He was with Andrew D. Fuller Company from 1903 to 1907, and the George A. Fuller Company from 1908 to 1918, being vice-president of the latter firm in 1917–1918. For the next six years Mr. Sawyer was with the Howes Brothers Company, and in 1924 formed the Sawyer Construction Company of which he is president. In his professional capacity, Mr. Sawyer has been responsible for the construction of many large educational and medical units, including Building 24 (used by the Radiation Laboratory during World War II) and the Sloan

Automotive Laboratory at M.I.T. He is chairman of the Newton Board of Appeal, president of the New England Peabody Home for Crippled Children, director of the Suffolk First Federal and Loan Association, and president of the Brae Burn Country Club. He is president of the Hahnemann Hospital and was formerly trustee of the New England Deaconess and Newton-Wellesley hospitals, and commodore of the Boston Yacht Club. He will come to his new post with a rich background of service to M.I.T., having been a member of the Alumni Advisory Council on Athletics in 1918–1919; a member of the Executive Committee of the Alumni Association, 1932–1934; vice-president of the Alumni Association, 1935–1937; and a member of the Alumni Council from 1932–1944.

NOMINATED TO SERVE ON THE M.I.T. CORPORATION

Underwood & Underwood

George J. Leness, '26

partner, Merrill Lynch, Pierce, Fenner and Beane, New York, in charge of that firm's underwriting activities; during recent years, governor, National Association of Security Dealers, New York section; vice-chairman, New York Group of Investment Bankers Association; President, the Bond Club of New York.

Robert T. Haslam, '11

Vice-president and Director, Standard Oil Company (N.J.); Director and member of executive committee, Ethyl Corporation; Professor of Chemical Engineering at M.I.T., 1920–1932; Director, American Institute of Chemical Engineers, 1928–1930 and 1932–1934; Vice-president, 1927.

Ferdinand Vogel

Volpe Studios

Luis de Florez, '11

President, de Florez Engineering Company, Inc. and Vice-president, Doubleday and Company, Inc.; Director of Special Devices Division, Bureau of Aeronautics, 1943–1945, becoming Deputy Chief of Naval Research, 1945; promoted to rear admiral, 1945; recipient of the Robert J. Collier Trophy in 1944 for achievement in aviation.

R.F.Haffenreffer,'95

chairman of the board, Narragansett Brewing Company and President of Hereshoff Manufacturing Company of Bristol, R.I.; President, M.I.T. Club of Fall River for many years; Director of the Museum of the American Indian, New York City; and recently appointed a member of the Rhode Island Port and Industrial Development Commission.

Beane of New York. To complete the unexpired term of the late Albert J. Browning, '22, XV, Luis de Florez, '11, II, President of the de Florez Engineering Company, Inc. and Vice-president of Doubleday and Company, Inc., has been nominated to serve on the Corporation until June 30, 1951.

New representatives on the National Nominating Committee to be elected this year (one from each district) are: *District 1* – H. B. Richmond, '14, VI; *District 2* – Portland, Maine, Club, James E. Barlow, '05, I; Montreal Club, Harold C. Pearson, '23, X; *District 4* – Albany Club, Charles E. Smart, '05, II; Buffalo Club, Gabe Hilton, '15, III; Rochester Club, Donald B. Webster, '16, X; *District 5* – New York Club, Winfield I. McNeill, '17, XV; Newark Club, George A. Chutter, '21, VI–A.

Tenney L. Davis: 1890–1949

TENNEY L. DAVIS, '13, Emeritus Professor of Organic Chemistry at the Institute until his retirement in 1942, died suddenly on January 25. Dr. Davis was born on January 7, 1890. He attended Dartmouth College for two years and then transferred to M.I.T. from which he was graduated in 1913 with the degree of bachelor of science in chemistry. Following graduate study at Harvard University, he was awarded the degree of master of science in 1915 and that of doctor of philosophy in 1917. He joined the staff of the Institute in 1919 as an instructor and became a full professor in 1938. He was widely known as an authority on the history of chemistry, and his publications include *History of Chemistry and Alchemy, Chinese Alchemy,* and *Scientific Methodology.*

Upon the entrance of the United States in World War I, Dr. Davis was commissioned a first lieutenant in the United States Army, and for two years was connected with the Ordnance Department, engaged in the inspection and development of explosives in this country and in France.

Dr. Davis was a frequent contributor to The Review and one of its editorial associates from 1933 to 1941, and again from 1946 to 1948. He was also a former associate editor of *Isis* and of *Archeion.* In 1947 he was appointed editor in chief of *Chymia,* an international annual devoted to the history of chemistry, and had completed work on one volume. He was a member of the American Chemical Society and had been secretary of the History of Chemistry Division. He had also been corresponding secretary of the American Academy of Arts and Sciences, and was a member of the *Deutsche Chemische Gesellschaft, Societe chimique de France, Societe Suisse de chimie, Paracelsus-Gesellschaft,* and the History of Science Society.

Hydrodynamics Laboratory

PLANS for immediate construction of a Hydrodynamics Laboratory and Model Ship Towing Tank at the Institute were announced by Dr. James R. Killian, Jr., '26, at the Midwinter Meeting of Boston Alumni which was held at Walker Memorial on February 5. The new laboratory, providing extensive facilities for research in the behavior of liquids and gases, will be built on M.I.T. property in Cambridge.

The laboratory and towing tank, the first project whose construction is undertaken in the $20,000,000 Development Program of the Institute, is expected to cost at least $500,000. Because its need is so urgent, construction of the building is now beginning, although available funds designated for its construction are being supplemented by unrestricted funds of the Institute. It is hoped that later contributions will release the unrestricted funds for other purposes.

In recent years the increasingly important applications of fluid flow in industry have served to make hydrodynamics a field of great industrial and engineering significance. At the present time there is acute need, both educationally and industrially, for a laboratory on the eastern seaboard adequately equipped for work in all aspects of fluid mechanics. This new building will meet the most acute of the Institute's current needs for facilities to broaden its educational and research program in new fields of engineering and technology.

Henry Richards: 1848–1949

HENRY RICHARDS, '71, whose centennial birthday last July 17 was reported in the November, 1948, issue of The Review, died at his home in Gardiner, Maine, on January 26. He was the oldest living alumnus of the Institute – to which distinction he fell heir upon the death of his brother, Robert Hallowell Richards, '68, in March, 1945 – and the second oldest living alumnus of Harvard University from which he was graduated in 1869.

Mr. Richards studied at the Dixwell School in Boston and spent part of his boyhood in England, graduating from Wellington College, Berkshire. In 1869 he was graduated from Harvard University and completed a course in architecture at M.I.T. in 1871. He practiced architecture for seven years in Boston before returning to his ancestral home in Gardiner where he operated the Richards Paper Company and also a pulp mill at South Gardiner.

A grandson of Gardiner's first mayor, Robert Hallowell Gardiner, Mr. Richards took an active part in civic matters and in art. He designed the Gardiner Public Library and for many years was head of the Maine Public Health Association. For more than 60 years he painted in many parts of the world, but he is best known for his water colors of the Maine Coast. Last December a group of his water colors were exhibited in the Bowdoin College Museum of Fine Arts. Mr. Richards also illustrated several books written by his wife, the late Laura E. Richards, daughter of Julia Ward Howe who wrote "The Battle Hymn of the Republic." Together, Mr. and Mrs. Richards operated Camp Merriweather for boys at North Belgrade.

Refresher for Science Teachers

FOR teachers in secondary schools who want a refresher course to bring them abreast of advances in science, the Institute will offer 50 fellowships for a six weeks' program of study this summer. This program is made possible by a grant of $62,500 from the Westinghouse Educational Foundation which will provide 50 M.I.T. Science Teachers' Fellowships of $250 each, to be awarded to science teachers each summer for the next five years. The program is open to science teachers in high and preparatory schools in New England and New York State who are college graduates or have equivalent qualifications to carry on the courses.

In announcing the fellowship program, Dr. James R. Killian, Jr., '26, President, described the project as a special service to teachers to enable them to keep pace with, and be qualified to interpret, the latest developments in science. In Dr. Killian's words:

> The foresight of the Westinghouse Educational Foundation in establishing this grant makes it possible for the Institute to offer its resources to a group of teachers whose influence in preparing youth for the problems of life is too often unappreciated. The program will bring into close fellowship men and women who have made the teaching of science their career. Their associations during their studies at the Institute will, we hope, send them back to their own classrooms refreshed and stimulated to carry on the important task of guiding their students through the first phase of higher education.

The Westinghouse Educational Foundation was created by the Westinghouse Electric Corportion in 1944 to support educational, scientific, and charitable activities. The Foundation provides funds for scholarships, fellowships, professorships, and other projects in connection with education and educational institutions.

Physics, chemistry, and mathematics in a combined lecture sequence will comprise one part of the fellowship program. The second part will cover general science, including recent developments in the fields of physics, chemistry, biology, meteorology, geology, and aeronautical engineering. The program will begin with registration on July 5, and continue through August 12.

Subjects to be discussed will be cosmic rays, nuclear physics, high-energy accelerators, radioactive tracers, large molecules, application of electronics to problems in biology, artificial stimulation of rain, determining the age of rocks by radioactivity, and problems of supersonic flight. In addition to formal lectures and laboratory illustration, teachers enrolled for the courses will have the opportunity to inspect the cyclotron and synchrotron at the Institute, the Van de Graaff electrostatic generator, the Acoustics Laboratory, the Spectroscopy Laboratory, Biology Laboratory, differential analyzer, and the subsonic and supersonic wind tunnels used for aircraft research.

To achieve the greatest degree of informality and teacher participation, frequent meetings will be held for general discussion of problems and methods of teaching science to boys and girls of high school and preparatory school age. On the recreational side, libraries and dining rooms and sports, swimming in the Alumni Pool and sailing facilities on the Charles River

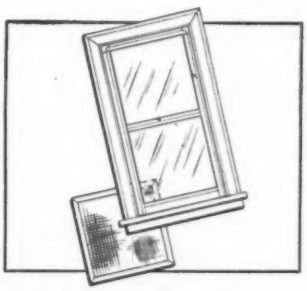
(*Continued on page 286*)

BUSINESS IN MOTION

To our Colleagues in American Business . . .

A rather recent development in the housing field is the combination screen and storm window. This is installed permanently, and greatly eases the otherwise difficult job of changing from screens to storm windows and vice versa. An exceedingly interesting new window of this general type has just been shown to Revere because it is made of a Revere brass.

The new window is entirely brass-framed, and fits flush into the house window, making it wind-and-weather tight. It has two brass-bound glass panes sliding in brass channels and held firmly in place by a simple brass slide. These panes, either or both, can be removed by hand in a few seconds from inside the house, and a screen panel substituted. At the bottom of the window is a narrow brass insert which can be removed if only a small amount of ventilation is desired. An additional feature is the provision of a slip joint with 5/8 inch play to take up expansion and contraction such as sometimes occurs, particularly in new houses, and to permit adjustment to older houses whose windows may not be quite true or uniform in dimensions.



Brass is a generic term, because copper and zinc can be successfully alloyed in various proportions. Thus there are many brasses. In addition, each is available in different tempers, gauges, and the like. The manufacturer of this window said that he had always regarded brass as a quality material, and never thought of using anything else. Since the method of fabrication requires severe forming, including some 180-degree bends, he came to Revere for assistance in selecting the right alloy, temper and annealing technique. The result is a window that is good looking, with a golden red color. Under difficult weather conditions, as at the seashore, it stands up and should outlast the house. Naturally, it cannot rust, rot, or warp.

Revere's collaboration with the window manufacturer is typical. When requested, we are delighted to tell all we know about our many metals, not only the brasses, but also bronzes, coppers, and aluminum alloys. These are made in various forms, including sheet and strip, bar, rod and wire, forgings, and extruded shapes. The latter, incidentally, in brass, copper and aluminum, have many architectural uses, including windows, thresholds, hand rails and the like.

We regard every material as having its own advantages, many of which are not shared with other products. That is why there are so many different Revere metals and alloys, offering a wide choice. This diversity of products, and complete knowledge about them, is customary in American industry. No matter what any supplier makes, he is well informed about it, and is only too glad to share his knowledge. After all, his customers make it possible for him to increase his business and his knowledge. In other words, you pay for both experience and materials. Are you using both?

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THE INSTITUTE GAZETTE

(*Continued from page 284*)

Basin will be available to the visitors, as well as sightseeing excursions.

Because of the limit in the number of grants and dormitory facilities available, applications for the courses must be received by April 1. Inquiries should be addressed to Professor Francis W. Sears, '20, chairman of the Summer Program for Science Teachers Committee, which includes George P. Wadsworth, '30, Associate Professor in the Department of Mathematics, and Professor Leicester F. Hamilton, '14, of the Department of Chemistry.

Fathers and Sons See Tech Movie

Approximately 800 M.I.T. Alumni, many with their sons of high-school age, attended the Midwinter Meeting of Alumni in Metropolitan Boston, held on Saturday, February 5, in Walker Memorial. In addition to having the opportunity to hear Dr. Compton in his new role as chairman of the M.I.T. Corporation, and Dr. Killian as the Institute's new president, Robley D. Evans, Professor of Physics, spoke on "Peacetime Atomic Energy" amplifying his remarks by means of slides and working models of several atoms. The electronic organ, gift of the Class of 1918, was put to good use as accompaniment to singing led by Orville B. Denison, '11, and the Kodachrome motion picture "M.I.T. – 1948" had its first public showing before an appreciative audience.

Informal talks by Dr. Compton and Dr. Killian recorded recent progress in the administration of the Institute and trends in higher education. Highlights of these addresses, such as the announcement of the building of the Hydrodynamics Laboratory and Towing Tank on page 284, are recorded in The Review. Not recorded elsewhere, as yet, is Dr. Killian's announcement that gifts to the Institute for the year 1948 were approximately $3,700,000 – the largest in any single year except when George Eastman made his generous benefaction.

In speaking of the peacetime applications of atomic energy, Professor Evans emphasized the motto to be found at the Brookhaven National Laboratory – "Atomic Energy Is Here for Good." After a brief outline of atomic structure, Professor Evans told his appreciative audience of the work which has been carried out during World War II in the preservation of blood (recorded in the December, 1946, issue of The Review), and outlined research now in progress in which radioactive tracer techniques were being applied in medicine and engineering.

The colored motion picture, to be exhibited before alumni groups, showed the principal activities taking place at M.I.T. during 1948. In addition to reflecting student life, the movie displayed the progress which had been made in the construction of the new Senior House, the Rockwell Cage, and the Charles Hayden Memorial Library, on which the major por-

(*Continued on page 288*)

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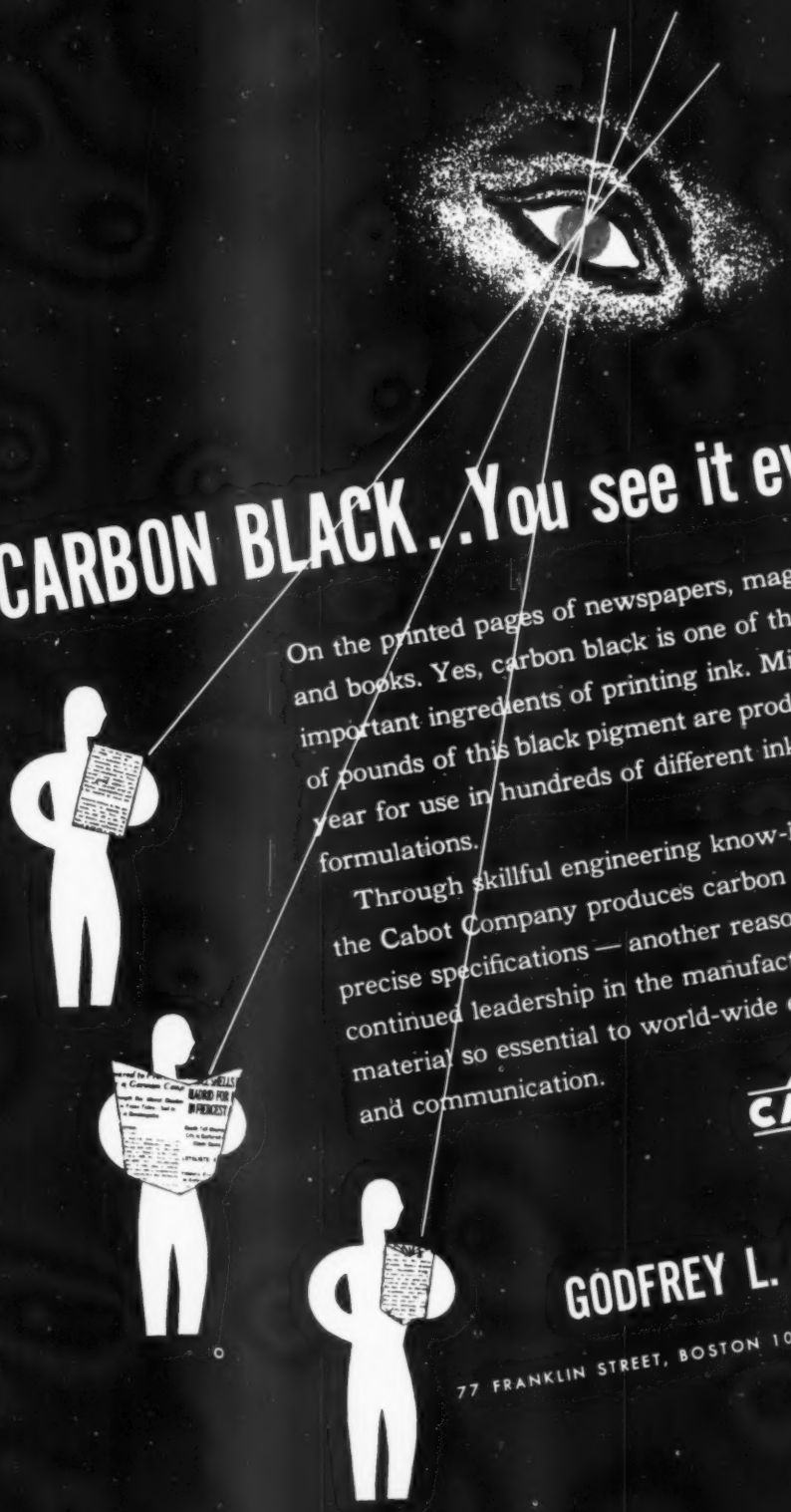

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(*Continued from page 286*)

tion of the steel work has been erected. Views of the Foreign Student Summer Project, the summer camps at East Machias, Maine, and at Crystal Farm, Nova Scotia, were shown, and the audience also enjoyed views of rowing and dinghy crews on the Charles River, as well as glimpses of the visitors at the last Open House event which was held in May, 1948.

Edward E. Bugbee: 1876–1949

With regret we announce the death on February 2 of Edward E. Bugbee, '00, who was associate professor of mining engineering when he retired in 1941. He was widely known in the field of mining and metallurgy and was an authority on fire assaying. He served from 1940 to 1941 as exchange professor at Stanford University.

Born in Brookline on October 5, 1876, Professor Bugbee received his early education in the public schools of that town, and was awarded the degree of bachelor of science in Mining Engineering and Metallurgy by the Institute in 1900. Following graduation, Professor Bugbee became an assistant instructor in metallurgy at M.I.T., and was promoted to instructor the following year. For three years, beginning in 1903, he was assistant professor of mining engineering and metallurgy at Iowa State College. In 1906–1907 he served in the same capacity at the University of Washington, and then rejoined the Institute as assistant professor of mining engineering and metallurgy.

Professor Bugbee served as an assayer for the Brookfield Mining Company in 1901–1902; as special agent for the United States Census in 1903, and at one time assistant geologist for the United States Geological Survey. During 1918 he served as assistant educational director of the Committee on Education and Special Training for the War Department.

Town Meeting

In a nation-wide radio broadcast on the Town Meeting of the Air on the evening of January 25, President James R. Killian, Jr., '26, joined George D. Stoddard, President of the University of Illinois, Clifton Fadiman, member of the Book-of-the-Month Club Board, and Paul H. Douglas, Illinois State Senator, in a discussion of the extent to which higher education in the United States is meeting the needs of modern man. President Killian emphasized the need to provide adequate means to train exceptional students in institutions able to maintain their academic and financial independence in the following remarks:

"At M.I.T. we were recently comparing notes with a distinguished British educator. He was astonished to learn that nearly 2,500,000 students are enrolled in American institutions beyond the high-school level. Since the comparable enrollment in the United Kingdom is nearer 50,000, we estimated, taking into account the relative populations of the two countries,

(*Continued on page 290*)

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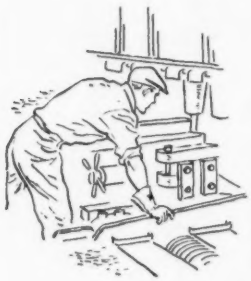

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THE INSTITUTE GAZETTE

(*Continued from page 288*)

that there are 20 times the percentage of our young people going to college as in Great Britain.

"I cite these enrollment figures to point up one of the great achievements and one of the great problems of our educational system. We are seeking to give more education to more people than any free nation has ever before attempted. In this sense we are approaching the basic requisite of a democratic society for universal education. But in our preoccupation with numbers, it is not surprising that we have not yet achieved some of the qualitative standards essential to well-rounded education.

"But when Walter Lippmann argues that American education creates 'no common culture, no common faith, no common body of principle, no common body of moral and intellectual discipline,' I would disagree both as to his implication that we have utterly failed and in his insistence that we should so regiment our people. I would like to point out also that the sheer numbers which already characterize our educational system and whose vastly increased augmentation is envisaged in the near future create enormous difficulties in the way of the achievement of Mr. Lippmann's objectives – even if we assume that all the latter are desirable.

"As I see it, certain common objectives are already beginning to emerge which are designed to meet the needs of modern man more fully than is presently the case. Let us state these goals briefly:

"First, we must provide social and political education. In American terms we must educate for citizenship in a democratic society. Here we are making steady progress, but much more remains to be done.

"Next, we must seek to develop the human being as a free and responsible individual, with moral standards and with inner resources. Here we must follow the precept of the great philosopher, Whitehead, that 'moral education is impossible without the habitual vision of greatness.'

"Third, we must provide our young people with those skills necessary to master a vocation or profession.

"Since I come from an institution devoted to professional education in science and engineering, my part in this discussion is to support the validity of this third objective. This I do enthusiastically but with the condition that vocational education must be fused with the other two objectives. Again Whitehead provides the prescription when he says that 'a merely well informed man is the most useless bore on God's earth. . . . What I mean is that every form of education should give . . . a technique, a science, an assortment of general ideas, an aesthetic appreciation, and that each of these sides of his training should be illuminated by the others.'

"I also believe that our specialized institutions – as, for example, our schools of science and engineering – have made important contributions, aside from their professional training, to the education of modern

(*Concluded on page 292*)

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THE INSTITUTE GAZETTE

(*Concluded from page 290*)

man. They have thrown off the burden of inert ideas encrusting some types of education. They benefit from the student motivation inherent in specialized study. They give their students the inner satisfaction of being able to do something useful and to do it well. Their curricula have pointed the way to a unity, a discipline, and a creative attitude that largely were lost when the classical curriculum became outmoded.

"So far I have suggested some of the goals and achievements which are bringing education more nearly in accord with the needs of modern man. We still have much to accomplish. We must find ways of financing our private institutions so that they may remain free and independent. We must continue the process of fusing social, moral, and vocational objectives. We must find ways of encouraging the exceptional student, so that he progresses at his own speed. We must encourage creative scholarship, minds 'forever voyaging through strange seas of thought alone.' We must seek to provide what Plato called 'the science of good and evil,' a true sense of the first-rate.

"If we can continue our progress in achieving these goals, we can educate for the needs of modern man."

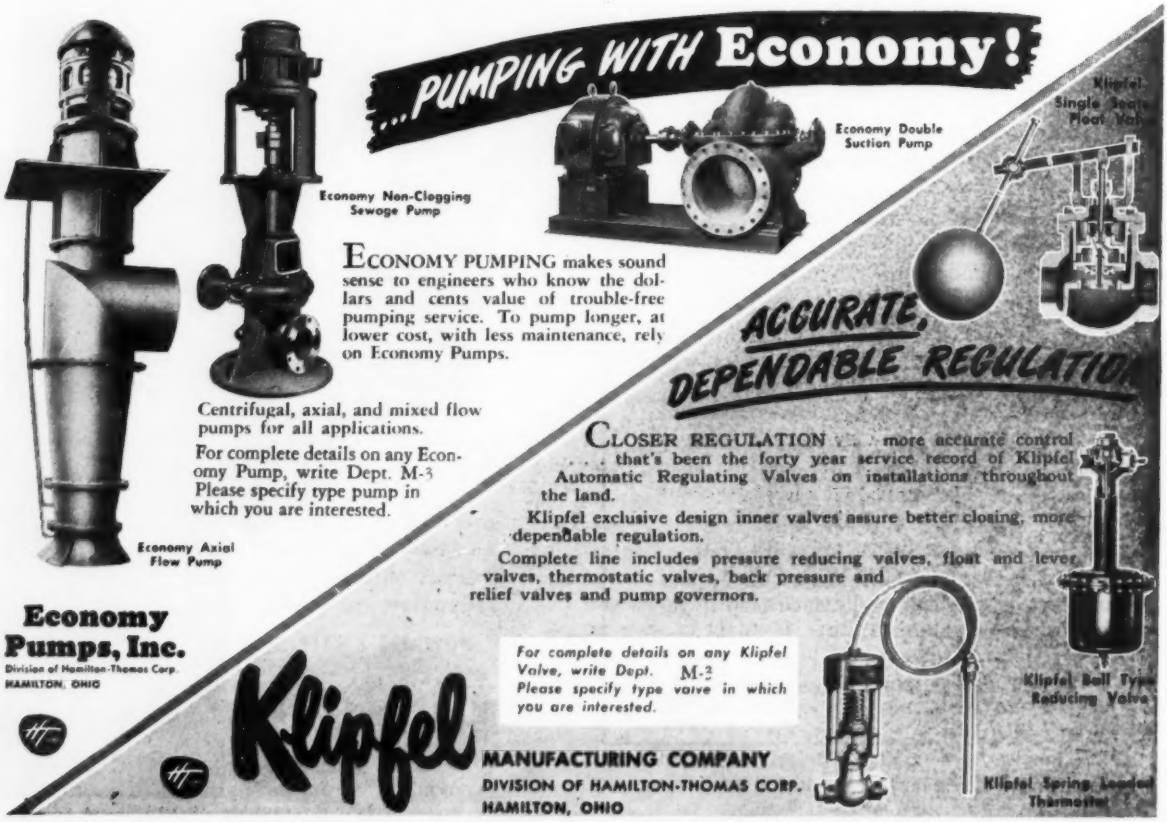
ARCHITECTURAL ACOUSTICS

(*Continued from page 280*)

useful knowledge by examining separately the many variables which enter into studio design. Ambient noise, vibration, restrictions imposed by size and shape, the effect of acoustical absorbents in altering the reverberation time, sound diffusion, and absorption of sound at different frequencies are all physical factors which can be measured by existing techniques. A knowledge of all of these factors is necessary before acoustical engineering can assume the quantitative status which characterizes many other branches of engineering.

At the present time, the second phase of the project is under way. The properties of the studio are measured primarily to determine whether they satisfy the following general physical characteristics: (1) freedom from extraneous noise; (2) freedom from faulty distribution of sound, that is, the avoidance of dead spots, echoes, and sound foci; (3) satisfactory reverberation control, that is, sufficient separation of individual sounds to satisfy speech intelligibility requirements and musical taste. To some extent, all of these factors involve subjective considerations so that a final and conclusive answer cannot be expected from physical measurements alone.

(*Continued on page 294*)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Most of us have, at one time or another

by J. L. SINGLETON
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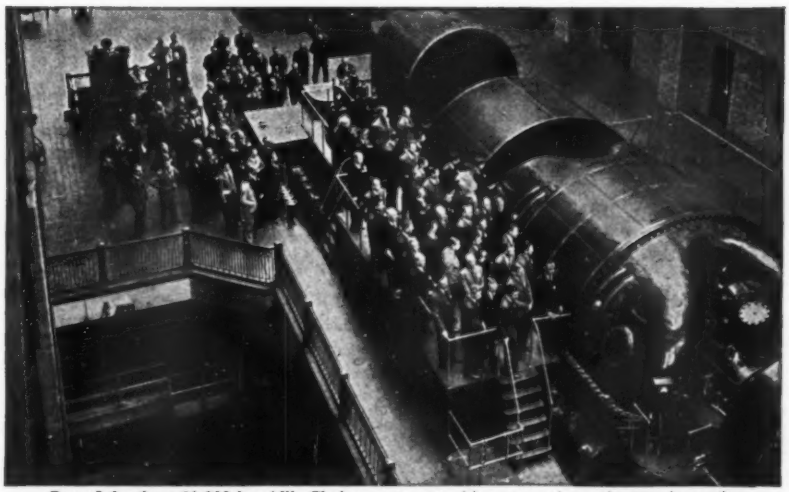
ALLIS-CHALMERS MANUFACTURING CO.
(Graduate Training Course 1928)



One of the three 80,000 kw Allis-Chalmers steam turbine generating units now in service in a big mid-western power plant. A fourth unit is being built, and a fifth is on order.

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J. L. SINGLETON

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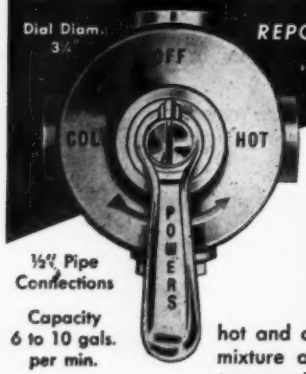

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ARCHITECTURAL ACOUSTICS

(*Continued from page 292*)

Techniques for Determining a Few of the Most Important Criteria in Architectural Acoustics

The reverberation time of a room can be measured by introducing into it a complex sound such as a warble tone, or bands of frequencies of filtered noise. After steady-state conditions have been reached, the sound source is suddenly stopped, and sound pressure is measured. From the decay curve of the sound pressure, plotted by a graphic level recorder, the reverberation time is calculated.

The sound field in a room can be determined by observing the sound pressure at one location due to a steady source at some other location. One method of doing this is to keep the position of the microphone and the sound source constant while the frequency of the source is changed slowly with time. As the frequency changes, the sound pressure at the microphone fluctuates due to the slowly changing patterns of standing waves in the room.

The diffusion characteristics of an enclosure can be measured by using a highly directional microphone. A diffuse sound field is one in which, on the average, there is no preferred direction of energy transmission. The orientation of the special microphone can be changed continuously in both angle and altitude. A graphic level record of the sound pressure at the microphone, as the orientation of the mounting is changed, will indicate the degree of diffusion provided by the room. Other methods for studying diffusion include mapping the sound field throughout the room while a steady sound is maintained, measuring reverberation time at many positions in the room, and determining the way in which the transmission of a steady sound between two points in the room varies with frequency.

The purpose of objective testing encompasses more than the determination of the physical characteristics of a room; the attendant development and evaluation of the instrumentation and theory in themselves are a logical and useful contribution to the field of room acoustics. Existing methods of measuring the acoustical qualities of a studio are admittedly inadequate. This condition is a drawback in one sense; yet, in another it affords a certain stimulus to research. It is hoped that more explicit techniques will some day be evolved; that a gradual sorting out of data and their implications may even be crystallized into the form of acoustical standards.

Subjective Aspects of Acoustical Engineering

When the design of a room is accomplished in accordance with the known theory and the best experience which is available, and when the physical acoustic properties of the room have been objectively measured, there is still no true measure of the acoustic quality of the room. A great deal of data on the characteristics of a room can be obtained through objective test, but the final analysis of "goodness" has to be based on subjective test, or, on human judgment, for the final criterion is the greatest possible auditory pleasure and intelligibility. It follows that, although physical tests can be made which guide acoustical design, it is ultimately necessary to consider the room in connection with the group of persons who are to use it for a specific purpose. Thus, there are auto-

(*Continued on page 296*)

JAMES M. BANGHART, SAN FRANCISCO

ABC

Here's another career story that'll interest college men H.C.C.

Things broke fast in 1940. In June I was graduated from Harvard with a degree in Physics. By October I was a Meteorological Cadet in the Air Force. Then, after five and a half years in the service, I was a civilian again. (He came out a Lt. Col. — H.C.C.)

That brought me to a career crossroad. Physics was too far in the past to return to, and meteorology didn't appeal to me as a lifetime job.

So I decided to draw up a description of the career I'd really like. Some sort of selling was indicated, because I don't like paper work, but do like to move around and talk to people. I wanted freedom of action--a business of my own that didn't require a lot of capital. I didn't want a ceiling on my earnings, nor a slow climb through a seniority system. And, after seeing the inhumanities of war, I felt that if, in addition, I could be of some public service, the job would be just about perfect.

Life insurance, it turned out, was the only field that fitted all these specifications. And that discovery brought me to the question, "Which company?". I began my search by calling on New England Mutual. Six weeks and eight companies later, after exhaustive comparisons, I was back at New England Mutual, taking an intensive training course. After that, I started out on my own in San Francisco, the city of my choice. (He sold over $300,000 of life insurance his first year H.C.C.)

Today, two and a half years later, I know I chose the right career and the right company. I'm still getting the finest training available, and I'm at home in "The best paid profession in the world." My income is in exact proportion to the time and effort I put in. And best of all, I enjoy the deep satisfaction of knowing I'm helping others--helping them achieve that vitally important goal, financial security.

James M Banghart

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Facts such as these helped James Banghart solve his career problem. If you'd like to know more, write Mr. H. C. Chaney, Director of Agencies, New England Mutual Life Insurance Company, 501 Boylston Street, Boston 17, Massachusetts.

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ARCHITECTURAL ACOUSTICS

(*Continued from page 294*)

matically injected into the problem certain physiological and psychological matters of sound perception and appreciation which have a direct bearing on engineering design and which need be taken into account. The correlation between the physical measurements and the subjective aspects in which a human being is considered a part of – or at least an element in – the overall engineering design, is an important element in teaching and research which, up to now, has not been fully exploited. This phase of the work also brings the student into direct contact with certain aesthetic problems, since rooms and studios should be good for the reproduction of music as well as of speech, so that at least some knowledge of music is essential to the acoustical engineer.

Thus, the third and final phase of the M.I.T. research program in room acoustics is the testing of the studio from a subjective or psychological standpoint. It is hoped to determine the acoustic "quality" of the studio, within the limitations set by subjective evaluation, by testing group reactions to speech and music, and by studying the relationship between subjective and objective data.

Within the last 20 years, a definitive method of evaluating speech intelligibility, called an articulation test, has been developed. Generally, an announcer reads specially prepared lists of sentences, words, or nonsense syllables to a group of listeners who have, preferably, some training in phonetic recording methods. The percentage of items correctly recorded by these listeners is called the articulation score; this percentage is taken as a measure of the intelligibility of speech. Since the nature of the spoken items helps to determine the resulting articulation scores, the test material must be carefully selected if a proper assessment is to be made. The speech sounds used are, for most testing purposes, representative of conversational speech, although they do not, in themselves, convey any meaning which might improve the score. Conforming to this general method, a listening group will be selected to record the intelligibility of speech lists when read in the studio. The articulation index obtained, in addition to giving a measure of quality, may possibly supply significant information when correlated with the sound decay characteristics.

In the evaluation of musical sound, there is no index of acoustic quality comparable with articulation data since understanding as it pertains to the spoken word does not enter into the appreciation of music; pleasure and clarity cannot be broken down into discrete measurable units. A qualitative index is difficult to obtain for there is the problem of having the same group of people listen to the same musicians playing the same music on the same instruments in two or more rooms successively without any appreciable time lag. Only then might a comparative study of room quality be feasible.

Needless to say, the rating of a room depends a great deal upon the musical taste and disposition of the listeners. Musical taste is certainly conditioned by

(*Concluded on page 298*)

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ARCHITECTURAL ACOUSTICS

(Concluded from page 296)

experience. Music has been heard extensively in reverberant rooms and much of the music of the past has been composed to be played in at least moderately reverberant rooms. Since the sound of a musical instrument cannot be freed from the influence of the room in which it is played, the reverberation characteristics of the room are vitally important to the quality of the music heard.

It is generally agreed that the acoustic conditions for speech are not the same as those for music. Moreover, different types of music are more or less designed for different reverberation characteristics. Therefore, ideally, every room should have many optimal reverberation times instead of only one. In spite of natural differences in musical taste, such experiments as have been performed have indicated that the tastes of different listeners are in fairly good agreement. A judgment of the musical quality of the M.I.T. studio is contemplated, although as yet the scope and methods have not been decided upon.

It is obvious that the aspects of the field of architectural acoustics are many and diverse, and it is clear why any approach to its problems must be a composite one. There is still much to be done and it is with co-operative research in electronics, physics, architecture, psychology, and acoustics that material advances will be made. It is felt that a new and successful approach has been made to integrated teaching and research procedure.

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THRUST PROBLEMS IN DAMAGED ARCH BRIDGES

(*Continued from page 278*)

designed for the safe absorption of the downward bending moments. Therefore, only sideways buckling will be considered. According to the Euler formula the thrust is given by:

$$P = \left(\frac{\pi n}{L}\right)^2 \left(\frac{EI}{C}\right)$$

P is the maximum allowable pressure (thrust) in pounds

n is 1 (because both ends of the column are unrestrained)

E is the modulus of elasticity of steel, assumed as 30,000,000 pounds per square inch

I is the moment of inertia of the weakest cross section of the structure about its vertical axis, in $(\text{in})^4$

c is the factor of safety, here assumed to be 2½

L is the length of the span in inches, here 672×12 inches

The two main trusses have a distance (d) of 200 inches, on centers, and the minimum steel area (A) in each single truss is about 100 square inches. Since there are two trusses, the moment of inertia is approximately the product of the steel cross section area ($2A$) and the square of half the distance (d) between the trusses (neglecting the moment of inertia of the truss cross section about its own center of gravity). In the form of an equation we may write the moment of inertia, in this case, as

$$I = 2A\,(\tfrac{1}{2}d)^2 = 2{,}000{,}000 \text{ inches.}^4$$

Substituting this expression into the equation for the maximum allowable pressure, we find the Euler formula to take the form

$$P = \frac{1 \times \pi^2 \times 30{,}000{,}000 \times 2{,}000{,}000}{2\tfrac{1}{2} \times 672^2 \times 144}$$

and numerically we find that

$$P = 3{,}700{,}000 \text{ pounds} = 1{,}850 \text{ tons}$$

The steel is subject to bending stresses in addition to stresses due to buckling. However, the allowable load limit in case of buckling, as computed above, is 1,850 tons or almost 10 times the anticipated load. Therefore it can be assumed that the bending stresses and stresses due to wind load will not be augmented substantially, and that the heavy SKR bridge can safely absorb this increase in stresses. As the present bridge is slated to be in use for at least 20 years, the adoption of the counterthrust lever appears to be advisable, and its installation would provide positive safety against any danger of further pier and arch deflections, with no special maintenance requirements.

(*Concluded on page 302*)

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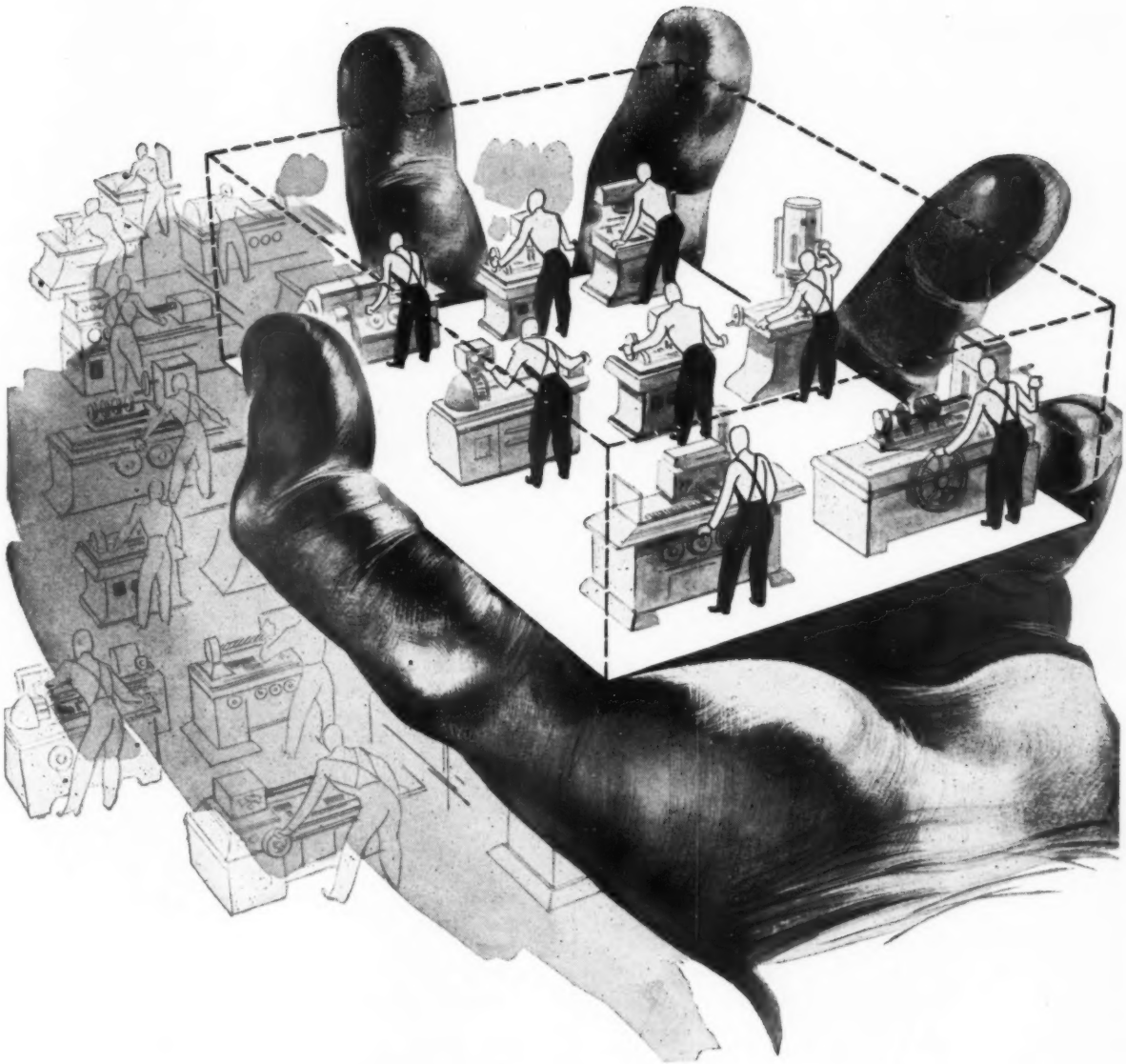

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THRUST PROBLEMS IN DAMAGED ARCH BRIDGES

(*Concluded from page 300*)

The superhighway between Stuttgart and Munich crosses the Neckar River on a number of reinforced concrete arches. The river spans were demolished, and it became necessary to support the last remaining arch to prevent its collapse as a consequence of the one-sided arch thrust. This thrust was causing the river pier of the three-point arch to give way towards the outside. A significant crack developed in the pavement above the other (abutment) pier. To prevent further deflection of the arch crown and horizontal movement of the river pier, a lever system was employed to support the arch, as shown in Fig. 7. A steel column was placed on the ground and a horizontal I beam was placed on top of it to serve as a lever. The long end of the lever was weighted down with a number of steel rail sections. The short end of the lever exerted a direct pressure upward on the reinforced concrete arch, thus relieving part of the horizontal arch thrust. The downward deflection of the arch crown was reversed. Any change in ground conditions could easily be absorbed by the movement of the free end of the lever. This method provides a particularly simple and effective means of reconstruction.

A study of the various measures taken in Europe in connection with abnormal thrust problems in multiple arch bridges might be useful, since floods and other catastrophic events might confront the engineer in this country with conditions not unlike those encountered in Europe.

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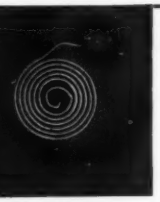

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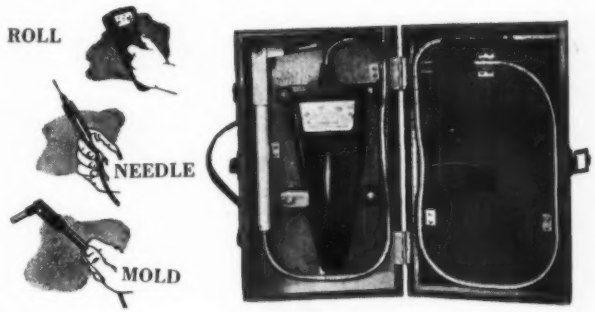

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SOIL CONSERVATION

(Continued from page 274)

It seems that engineers, as well as all other technical personnel in conservation, must have a fundamental understanding of the interrelationships between living things and their environment. They must furthermore be conscious of other technical fields having a bearing upon their own, and be capable of obtaining help from the technicians in those fields. Thus the work of the engineer can become actually integrated with work in other fields. For those of us trained in a specialized field of knowledge it may seem no responsibility of ours to relate our work to that of others. The average technician may get by that way. The one who will advance in his special field in the days ahead will be the one who knows how to relate his work effectively to that of others.

Resources versus *Population*

Special emphasis should be given to the importance of the conservation of natural resources. This can be done by reference to a simple equation:

$$L = E/P$$

In this equation L represents level of living; E represents environment or resources; P represents population. When one of the elements in any such relationship varies, the others vary, as you well know.

We have discussed one of the elements in our natural environment, the soil. We might have discussed any other, renewable or nonrenewable, with much the same effect upon this relationship. Soil as a useful resource is declining. It is scarcely anywhere as productive as it was once. It has been depleted of fertility, and it has been physically destroyed by erosion in many parts of this country and of the world. Granting that we may be able to do a great deal through modern methods of controlling erosion and better techniques of land use, even so the amount of productive land in the world is limited. In the United States we now have about three acres of cultivable land per person. This is a little better than the two and a half acres required to produce enough food to keep a person in good health, to say nothing of the cultivated land needed to produce other agricultural products. Many countries of the world have much less.

What of population – the P of the equation? In the year 1650 there were only 500,000,000 people in the world. In 1940 there were five times that many –

(Concluded on page 306)

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SOIL CONSERVATION

(*Concluded from page 304*)

2,500,000,000. The world's population is increasing at the rate of 20,000,000 per year. The population of the United States increased 2,500,000 in 1946. The world's population in the past hundred years has doubled. This is a sobering fact. Some students predict a population as high as 185,000,000 in the United States by 1975. What of the two and a half acres of good cropland needed to grow food for each of us then?

What then of the level of living – the *L* of the equation? If *E* (the environment in terms of resources) is constant in that natural resources are limited, and *P* (population) is increased, then *L* (level of living) must become less, and so it has in many parts of the world.

Consideration of such a relationship reveals that the increasing pressure of world population upon the resources required to support it is one of the most vital problems of the present day. What we are doing to use our soil resource more wisely is one of the attempts to help solve this problem. Food and many other agricultural products come from the soil and so far as we can foretell now, will continue to come from the soil for many long years ahead.

In soil conservation, as in the struggle to use all our resources so that they may support the peoples of the world today and tomorrow, the engineer has an important and conspicuous responsibility. He will need to lend his most enlightened support to programs of conservation in this country and in other countries during the years ahead. In this respect, M.I.T. takes a most progressive step by offering, in 1949, a course in Principles of Conservation. Without the help of the engineer, closely correlated with the efforts of many others working in related fields, we cannot achieve conservation of the soil or the wise use of any of the natural resources upon which the welfare of peoples fundamentally depends.

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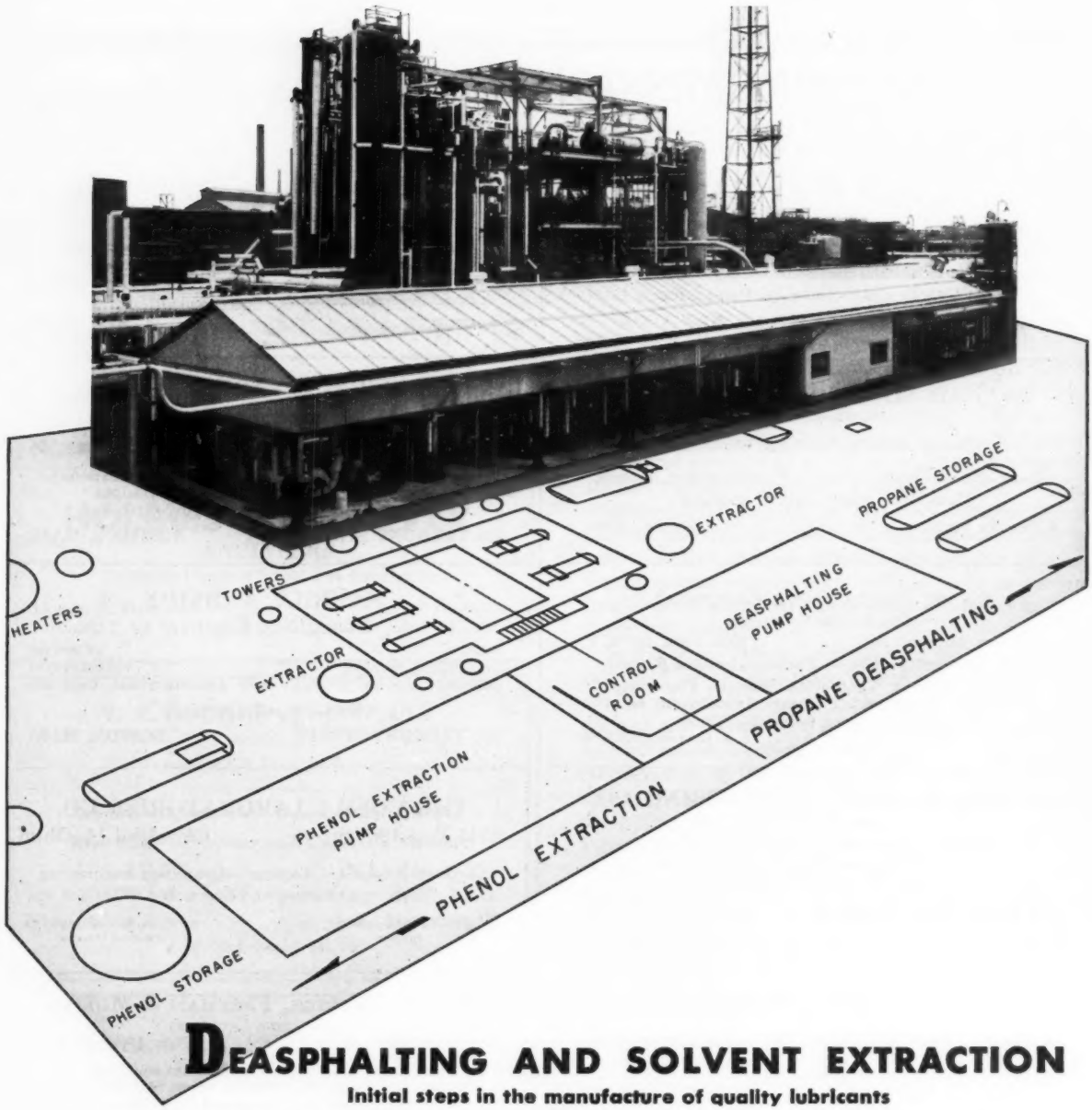

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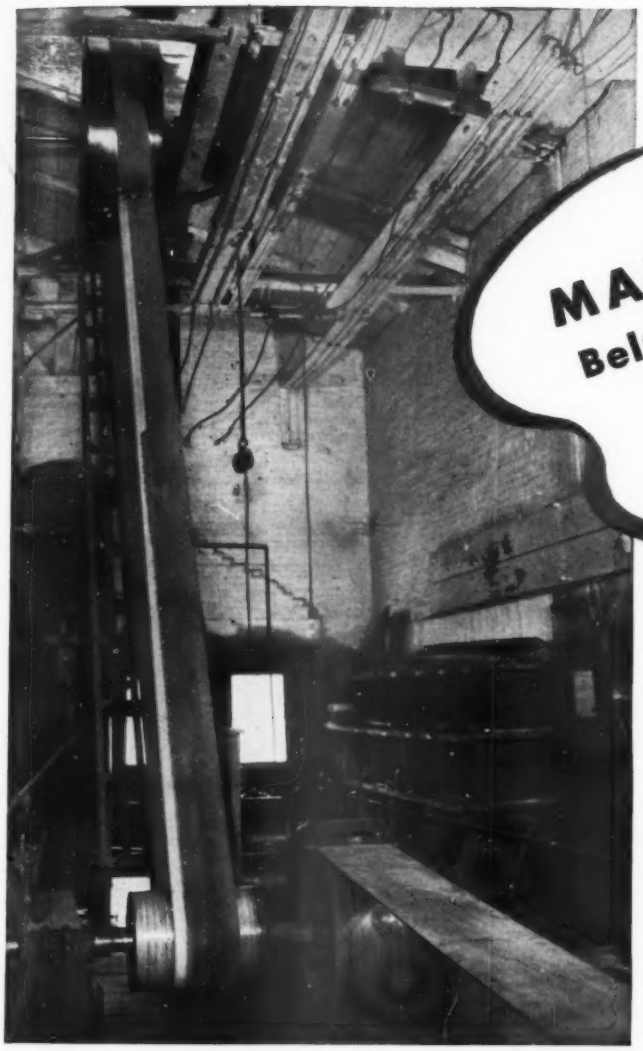

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We quote directly from a letter from Mr. F. E. Steele, Superintendent:

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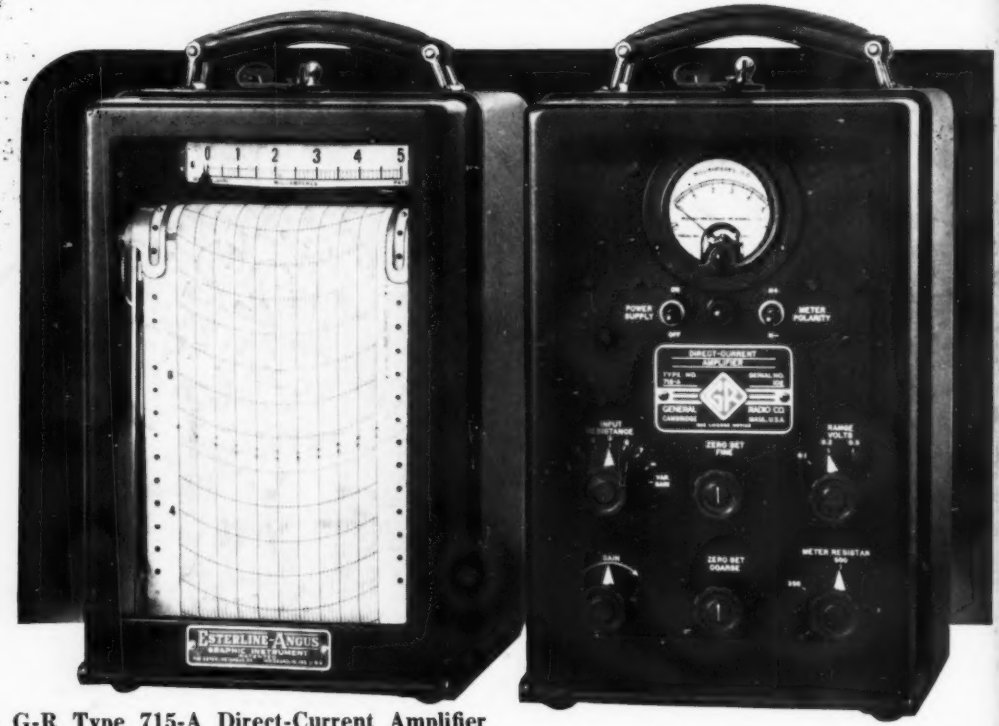

• **The G-R Type 715-A Direct-Current Amplifier** was designed particularly for operation with the Esterline-Angus 5-milliampere recorder to be used as a calibrated recording voltmeter. With appropriate selection of built-in input resistances the combination also is a recording milliammeter or microammeter.

The amplifier can be used in automatic process control circuits where its output operates relays to control the device which feeds the input of the amplifier. It may be operated from frequency meters, sound and vibration measuring equipment, photoelectric cells, resistance strain gauges, resistance thermometers and other similar devices.

The Type 715-A D-C Amplifier has high gain, operates from an a-c line, is very simple to use, requires practically no attention, can be used for very long periods for continuous recording, is exceptionally free from effects of line voltage variation, and has a wide range of built-in input voltage and resistance combinations.

Full-scale output has been made 5 milliamperes to operate the 5 m-a recorder. This full-scale output can be obtained on calibrated ranges from input voltages of 0.1, 0.2, 0.5 and 1.0 volt. The input resistance can be varied between 100 ohms and 10 megohms in powers of 10 by means of a panel switch.

The amplifier is supplied either in a cast metal case to match the Esterline-Angus recorder, or in a walnut cabinet.

SPECIFICATIONS

RANGE: Four switch selected calibrated ranges supplying 5 m-a linear output in recorder circuit for input voltages of 0.1, 0.2, 0.5, and 1.0 volt.

ACCURACY: Approximately 1% as a calibrated voltmeter.

INPUT: From 100 ohms to 10 megohms, in powers of 10, to adjust input resistance and permit use of instrument as calibrated millivoltmeter or microammeter. Short- and open-circuit positions on selector switch. For over one volt input variable gain control provided to adjust voltage to desired value. Input resistance is then about 150,000 ohms.

GRID CURRENT: In input circuit is less than 0.002 microampere.

OUTPUT CIRCUIT: Designed to operate 5 m-a meter on panel, or Esterline-Angus 5 m-a recorder. Provided with compensating resistance to match external device to normal resistance of 1,000 ohms.

TYPE 715-AE D-C AMPLIFIER
(Metal Case) $345.00

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